13 Appendices

13.1 SMP95 Monohull Regular Wave Module Input File Description

13.1.1 SMP Input Record Overview

This section gives further information on the data that is entered in the Regular Wave input file. In VisualSMP, this data is entered through dialogs as described in Section 4. However, the ASCII file may be edited by hand (carefully), with data described here.

The input to be developed for the regular wave module consists of hull form data, loading data, and appendage data. The data is made up of data record sets. The number of data record sets required for the regular wave module is 19; however, the number of records within each set will vary according to the individual ship particulars and user requirements. Table 4.1 summarizes the 19 data record sets.

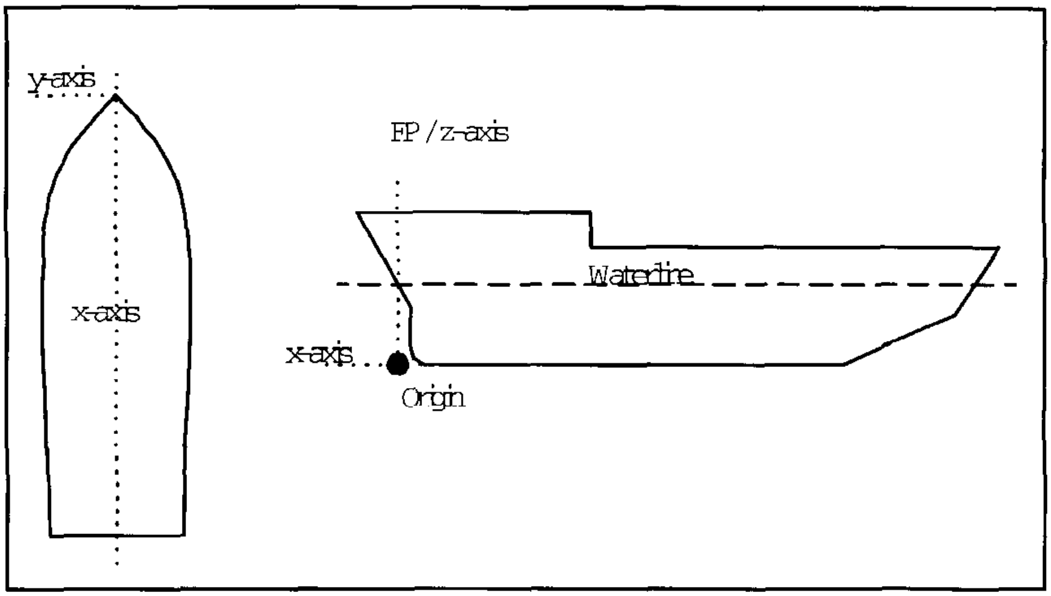
Table 4-1: Record Set Summary

Record Set Definition

1. Title
2. Program Options
3. Physical Units
4. Hull Particulars
5. Loading Particulars
6. Underwater Hull Geometry
7. Sonar Dome Particulars
8. Bilge Keel Particulars
9. Fins Particulars
10. Skeg Particulars
11. Propeller Shaft Particulars
12. Propeller Shaft Bracket Particulars
13. Propeller Particulars
14. Rudder Particulars
15. Passive Stabilizers
16. Sinkage and Trim
17. Wave Profile
18. Roll Damping Model
19. STOP

Users should be aware that when using fixed file formats, integers must be keyed at the correct location, i.e., right justified within their specified fields. Floating point (real) numbers and character information may be placed anywhere within the specified fields (unless otherwise indicated in the data record sets).

The reference system, which is used for input data to SMP is illustrated in Figure 4-1. The origin (station 0) for this system is defined as the intersection of the ship's forward perpendicular and Station 20.0 defined at the aft perpendicular. The y-coordinate of this system is measured from the ship's centerline with y positive to port. The z-coordinate of this system is measured from the ship's baseline with z positive up. The units of y and z must be the same, but can be expressed in either feet or meters.



This reference system is used to define the input values for the underwater hull geometry, hull and loading particulars, appendage information, and point locations at which motions are computed.

13.1.2 Record Set Description

This particular section on the description of the record sets is an illustrative formulation on how to prepare a regular wave input file. It is an important section to which the user should constantly refer before running a ship through regular wave module. Thus, careful reading of this section is highly recommended.

Note that each data record set is made up of one or more records. Any specific data record set that should not be used is represented by a blank record. It should also be noted that some records within a data record set may be eliminated or skipped, depending on the user's needs and information. The method used to describe each data record set is to list each record, its FORTRAN format, and the variable(s) contained on it.

Record Set 1: Title

Record 1 – FORMAT (20A4)

- [TITLE] (Character) – columns 1-80, title information.

This is a one-record data set consisting of up to 80 characters. The title should be centered on the record and usually includes the ship, date, project, and / or other parameters that make this run unique. This information will be output at the top of each printed page. For historical reference, the user may desire to site the ship's trim on this title record.

Record Set 2: Program Options

This is a one-record data set, which enables the user to control the extent of program execution and the amount of data printed. Five option variables are contained on this record set.

The first variable, OPTN, is the program run option. The amount of calculations and thus the run time is controlled by this option. It is recommended that the first time OPTN=2 or 3 is selected, that the user save (catalog) the Base Ship Coefficient file (COFFIL,TAPE3. The remaining four option variables, VLACPR, RAOPR, RLDMPR, and LRAOPR select specific output tables to be printed.

Record 1 – FORMAT (415)

- [OPTN] (Integer) – column 5, major program control option.

  1 – Hydrostatic calculations only. Printout consists of an input record "echo," and input record description, and tables of ship and appendage particulars.

  2 – Full run of SMP for all motions. First part of printout is the same as for OPTN=1. In addition, tables of Response Statistical Values / encounter modal periods (RSV / T_{oe}) are printed for the sea states specified by the user in Data Record Set 14. The following files are written: Origin Transfer Function file, and a Speed Polar file. The Speed Polar file is used for off-line plotting of the RSV data.

If no value is selected for OPTN (i.e., OPTN=O), a full run of SMP is made as in OPTN=2.

- [VLACPR] (Integer) – column 1O, velocity and acceleration print option. Because the standard SMP output is extensive, care should be exercised when selecting this option. The RSV printout will triple when this option is selected. The velocities and accelerations are always written out to the Speed Polar file, so the user may prefer to plot this data rather than print it out.

  O or blank – blank – No velocity and acceleration printout.

  1 – Print out the velocity and acceleration RSV / T_{oe} tables.

- [RAOPR] (Integer) – column 15, Response Amplitude Operator (RAO) print option. The RAO tables are printed for the six-degree-of-freedom motions for long-crested seas (user specifies significant wave heights in Data Record Set 14), and for each speed, heading, and wave frequency defined in SMP. It should be noted that the lateral motion RAO's are nonlinear with sea state. The user should also be aware of the large amount of printout generated when this option is selected. An RAO file is generated only when the RAOPR option is selected.

  O or blank – No RAO printout.

  1 - Print out RAO tables in addition to the RSV / T_{oe} tables.

2 – Print out RAO tables and RSV / T_{oe} tables.

- [RLDMPR] (Integer) – column 20, roll damping print option. This printout is extensive. If RLDMPR > 0 then roll decay value "n" is printed out. If RLDMPR < 0 then nondimensional B_44 is printed. The later is also labeled "n", although strictly speaking it is not.

  O or blank – No roll damping tables printed.

  1 - zero speed potential speed added mass and damping, summary of roll damping.2 - above plus damping and percent of total damping by

  device (hull, bilge keel, etc).3 - above plus damping and percent of total damping by physical mechanism (wave making, lift, etc)

- [LLRAOPR] (Integer) – column 25, RAO print option out the vertical shear force and vertical bending moment response amplitude operators (RAO) and phase angles. A load RAO file is generated only when the LRAOPR option is selected.

  O or blank – No load RAO tables are printed.

  1 – Print out the load RAO's and generate a load RAO file

- [ADDR](Integer) – column 30. Option to turn on the added resistance calculation.

  0 or Blank – No Added resistance tables are printed.

  1 – Print out Added resistance tables.

- [VGOPTN](Integer) – Column 35, The variable geometry option combined with trim results in the hull being distorted as the sections are simply moved vertically. Consequently, results will be best if the trim is relatively small. Also, with the variable geometry option, segment is generated as specified; the geometry input is separated from the segmentation specification. A rectangular section, for example, requires only three input points, even if finely segmented. Sections may enter or leave the water. It will work for "normal" monohulls, unusual shapes may result in difficulty. The resulting immersed form must be a monohull. Sections must be simply connected; a hull with a large protruding bulb and a large protruding above water bow will fail.

  0 – Existing Static stations definition.

  1 – Allow Sinkage and Trim.

- [RDMSEL](Integer) – column 40, Roll damping model selection option is for developmental use only.

  0 – No selection, use defaults.

  1 – Read Options from record set 18.

Record Set 3: Physical Units

Record 1 – FORMAT (2A4,2X,2F10.4,F10.8)

- [PUNITS] (Character) – columns 1-8, allowable physical units, e.g., units of length: FEET or METER. If METER does not appear in columns 1-5, SMP will default to FEET.

- [RHO] (Real) – columns 11-20, mass density of water in PUNITS. For example, if PUNITS=FEET, use a value of 1.9905 slugs/ft; or, if PUNITS=METER, use a value of 1025.82 kg/m3.

- [GRAV] (Real) – columns 21-30, acceleration of gravity in PUNITS. For example, if PUNITS=FEET, use a value of 32.1725 ft/sec; or, if PUNITS=METER, use a value of 9.8062 m/sec.
- [GNU] (Real) – columns 31-40, kinematic viscosity in PUNITS. For example, if PUNITS=FEET, use a value[4] of 0.00001279 ft / sec; or, if PUNITS=METER, use a value of 0.00000119 m2 / sec.

These values determine the physical constants used in the calculation of the pressures and motions. The suggested magnitudes of these units were taken directly from the ITTC tables. PUNITS has two allowable options (FEET and METER) which enable the user to specify whether English or Metric units will be used for the input data.

Record Set 4: Hull Particulars

Record 1 – FORMAT (3F10.4,F10.2,3F10.4)

- [LPP] (Real) – columns 1-10, length between perpendiculars.
- [BEAM] (Real) – columns 11-20, beam at Station 10.
- [DRAFT] (Real) – columns 21-30, draft at midships.
- [DSPLMT] (Real) – columns 31-40, displacement in long tons (salt water) if PUNITS=FEET or mass in metric tons if PUNTIS=METER.
- [VKDES] (Real) – columns 41-50, design speed in knots. The design speed, in conjunction with the next variable, VKINC, is used in determining the total number of speeds and the maximum speed for which motions are computed. For example, for VKINC=5 (default), the ship speeds used in the computations are: 0, 5, 10.,,,. VKDES. In this case, if VKDES is not divisible by 5, the next highest speed divisible by 5 is used as the maximum speed.
- [VKINC] (Real) – columns 51-60, increment for speed. If zero or blank, a default value of 5 is assigned.
- [AMODL] (Real) – columns 61-70, model length. Used for Reynolds number scaling in scaling in skin friction and bilge keel calculations when model results are desired (change RHO and GNU to fresh water values). Set AMODL to zero for full-scale calculations.

The hull particulars are in PUNITS units and are printed in the hydrostatics output. The displacement printed in the hydrostatic table is calculated from the hull geometry and should be checked with the input value to see if it is within tolerance. The maximum number of speeds used in the computations is 8; therefore (VKDES/ VKINC)+1 should always be <8. Zero knots is always the first speed.

Record 2 – Format(8F10.4) If VKDES is less than 0

- [VK(I)](Real) – Array of ship speed in ascending order.

Record Set 5: Loading Particulars

Record 1 – FORMAT (6F10.4)

- [GMNOM] (Real) – columns 1-10, nominal value of GM in PUNTIS, which should include any free surface corrections. The actual value of GM used in SMP is computed as part of the hydrostatic calculations. GMNOM is provided as a check for the user on the calculated GM value. However, the user should be aware that SMP uses GMNOM to compute a nominal value of roll period, which, in turn, determines the range of frequencies and modal wave periods used in the motion calculations. One set of frequencies and modal periods is selected for a nominal

1. Based on salt at one atmosphere, 15 ° C (59 ° F).

period < 15 seconds and a different set is selected for a nominal period > 15 seconds. The nominal roll period is determined as,

$$T\phi = 2\pi\sqrt{1.25 \times (KROLL \times BEAM)^2 / (GRAV \times GMNOM)}$$

where KROLL is input in this Record Set, BEAM is input in Record Set 4, and GRAV is input in Data Record Set 3. GMNOM must always be > 0.

- [DELGM] (Real) – columns 11-20, free surface correction, if any, in PUNITS. Always positive and included in GMNOM, DELGM does not affect the location of the metacenter (KM).

- [KG] (Real) – columns 21-30, distance from the keel to the center of gravity at the LCB in PUNITS. The KG value that is input corresponds to the uncorrected GM. The KG value printed in the hydrostatic table includes any free surface correction. (KG+DELGM).

- [KPITCH] (Real) – columns 31-40, pitch radius of gyration divided by LPP. A typical value of KPITCH is 0.25.

- [KROLL] (Real) – columns 41-50, roll radius of gyration divided by BEAM. KROLL is referenced to the vertical center of gravity. A typical value of KROLL for frigates is 0.35.

- [KYAW] (Real) – columns 51-60, yaw radius of gyration divided by LPP. A typical value of KYAW is 0.25.

Record Set 6: Hull Geometry

The underwater part of the hull is described in this record set by stations in the x direction and by station offsets in the y and z directions using the Input Reference System as described above. An important consideration in preparing the offsets is to include the skeg(s) when describing the aft hull lines. In addition to perhaps losing a significant amount of displaced volume, elimination of the skeg(s) from the hull description alters the computation of roll damping due to hull shape. A separate input description of the skeg(s) as an appendage will also be required in Record Set 8 to determine lift damping.

Record 1 – FORMAT (15)

- [NSTATN] (Integer) – columns 4-5, number of stations (maximum of 25). NEXT RECORDS ARE REPEATED FOR NSTATN STATIONS.

- [NLOADS] (Integer) – columns 9-10, number of stations where vertical loads are to be calculated (maximum of 10).

- [NBB](Integer) – column 15, Flag to denote the existence of a bulbous bow.

  0 – no bow bulb

  1 – large destroyer-type bow bulb.

RECORD SET 6BP - required only if VGOPTN .eq. 1 NBP, KNFBP 2I5

- NBP - Number of points for bow profile
- KNFBP - 0 no knuckles on bow profile

  1 read array of knuckle flags

  if NBP .gt. 0 then read

- (BPST(J),J=1,NBP) 10X,10F7.2
- (BPWL(J),J=1,NBP) 10X,10F7.2

where BPST are the stations of points on the bow profile and BPWL are the waterlines of points on the bow profile, going from the keel to the deck.

if KNFBP .eq. 1 then read

- (KNPBP(J),J=1,NBP) 10x,10(6x,i1), repeated for as may lines as required

The maximum number of points on the bow profile is equal to the maximum number of points on a station (without the reduction for VGOPTN = 1 noted below.)

Record 2 – FORMAT (F10.4,3I5)

- [STATN] (Real) – columns 1-10, station number.

The stations are input in the order they occur along the ship, starting from the forwardmost underwater station and ending at the aftmost underwater station. Stations forward of the FP and aft of the AP are allowed. For example, -0,28, 0,25, 0.5, 1.0, 2.0,..., 10.0, , 19.0, 20.0, 20.5. Station 10 must always be included.

- [NSOFST] (Integer) – columns 14-15, number of station offsets (maximum of 10). NSOFST is variable from station to station, with a value of 0 allowed if there are no offsets at a particular station (usually the FP and AP). The minimum value of NSOFST is 3 for stations with offsets. Stations such as the FP and AP with NSOFST=0 are included for purposes of longitudinal integrations.

- [KNPF] (Integer) – column 20, indicator as to whether section contains knuckles.

  O – No Knuckles.

  1 – Read knuckle array..

- [NPTOS] (Integer) – column 25, indicates which point to cut the geometry off at if VGOPTN is set.

Record 3 – FORMAT (F10.4,10F7.2)

- [STATN] (Real) – columns 1-10, station number.

- [HLFBTH(i)] (Real) columns 11-17, 18-24,..., [(NSOFST – 1)*7+11], station y-coordinates for NSOFST offsets (referenced to the centerline, always positive).

Record 4 – FORMAT (F10.4,10F7.2)

- [STATN] (Real) – columns 1-10, station number.

- [WTRLNE(i)] (Real) – columns 11-17, 18-24,..., [(NSOFST – 1)*7+11] – [NSOFST*7+10], station z-coordinates for NSOFST offsets (referenced to the centerline, always positive).

Record 5 – FORMAT (10x,10(6x,I1)) required if KNPF is equal to 1

- [KNP(i)] (Real) – columns 18,24,..., [(NSOFST – 1)*7+11] – [NSOFST*7+10], flag to indicate a knuckle in the station data.

RECORD SET 6SP - required only if VGOPTN .eq. 1

- NSP, KNFSP 2I5

- NSP - Number of points for stern profile
- KNFSP - 0 no knuckles on stern profile
  1 read array of knuckle flags

if NSP .gt. 0 then read

- (SPST(J),J=1,NSP) 10X,10F7.2
- (SPWL(J),J=1,NSP) 10X,10F7.2

where SPST are the stations of points on the stern profile and SPWL are the waterlines of points on the stern profile, going from the keel to the deck.

if KNFSP .eq. 1 read

- (KNPSP(J),J=1,NSP) 10x,10(6x,i1), repeated for as may lines as required

The maximum number of points on the stern profile is equal to the maximum number of points on a station (without the reduction for VGOPTN = 1 noted above.)

If NLOADS is greater than 0 then the following record is repeated NSTATN times to define the ship weight distribution.

RECORD SET 6F

STATN,SWGHT,SKG,SKROLL,SKPITCH,SKYAW (6F10.2)

where

- STATN= the station number. Stations for this section of input must be exactly the same stations as for the definition of the hull offsets.

- SWGHT= a lumped weight which represents an apportionment of the weight curve to STATN. Note that weight is expected to be in long tons (force) if PUNITS="FEET", or metric tons (mass unit) if PUNITS="METER".

- SKG= vertical location of the center of gravity of the weight apportioned to the station, feet or meters, positive above baseline.

- SKROLL= the roll gyradius of the weight apportioned to the station, feet or meters.

- SKPITCH= the pitch gyradius of the weight apportioned to the station, feet or meters.**

- SKYAW= the yaw gyradius of the weight apportioned to the station, feet or meters.**** these values are not currently used but are included for future use.

RECORD SET 6G - required if NLOADS > 0 (XLDSTN(K),K=1,NLOADS) (8F10.4) where

- XLDSTN = the station numbers at which loads are to be calculated.

Note that the specified station numbers must correspond exactly to one of the station numbers specified earlier.

Record Set 7: Sonar Dome Particulars

RECORD 7A - always required:NSDSET Integer I5Number of sonar domes - must be 0 or 1

RECORD 7B - required if NSDSET > 0:

SDFST,SDAST,SDRWL,SDTWL Real 4F10.4

Station of the forwardmost point of the dome, station of the aftermost point of the dome, top of the dome (typically the baseline = 0.0), and the lowest point of the dome. The sonar dome is assumed to be a standard SQS 26 type of dome, modeled as a lifting surface with a lift curve slope from experiment. Only one per ship is allowed.

Record Set 8: Bilge Keel

Record 1 – FORMAT (15)

[NBKSET] (Integer) – column 5, number of sets of bilge keels (maximum of two sets allowed).

NEXT RECORDS ARE REQUIRED FOR EACH BILGE KEEL SET, SKIP IF NBKSET=O.

Record 2 – FORMAT (15,5X,3F10.4)

[NBKSTN] (Integer) – column 5, number of stations crossed by this bilge keel set.

[BKFS] (Real) – columns 11-20, the forward point of the bilge keel set expressed as a station number, e.g., Station 12.25.

[BKAS] (Real) – columns 21-30, the aftermost point of the bilge keel set expressed as a station number, e.g., Station 12.25.

[BKWD] (Real) – columns 31-40, the span (width) of the bilge keel set in PUNITS.

Note: NBKSTN is the number of stations crossed by this bilge keel set, so that a bilge keel going from Stations 7.75 to 12.25 will cross 5 stations, 8, 9, 10, 11, and 12 with NBKSTN=5 (see Figure 4-3a). In addition, if a bilge keel should start or end exactly at a station, that station must be included.

NEXT RECORD REPEATED FOR THE NBKSTN STATIONS OF THIS BILGE KEEL SET.

Record 3 – FORMAT (4F10.4)

[BKSTN] (Real) – columns 1-10, bilge keel station. Value for BKSTN must correspond exactly to station numbers (STATN) input in Record Set 6.

[BKHB] (Real) – columns 11-20, y-coordinate (positive) where bilge keel attaches to hull.

[BKWL] (Real) – columns 21-30, z-coordinate (positive up) where bilge keel attaches to hull.

[BKAN] (Real) – columns 31-40, angle (positive in degrees) that the bilge keel makes to the horizontal.

These records specifically locate the bilge keel in the Input Reference System and define the angle that the bilge keel is attached to the hull for each station.

Record Set 9: Fin Particulars

Modified from DATA CARD SET 11 NOTE: relative to SMP84/87, variables IAGC, FALIM and FVLIM are new to Record a. The entire Record b is new.

RECORD 9A - always required

NFNSET,IACTFN,IFCLCS,IAGC,FALIM,FVLIM (4I5,2F10.5)

where NFNSET = Number of fin sets, maximum of 2.

If NFNSET is zero no further fin input is required, and the values of the remaining variables are immaterial.

IACTFN = Active/passive fin flag.

IACTFN = 0 for passive fins.

IACTFN = 1 for active fins.

IFCLCS = Input effective lift curve slope flag.

IFCLCS = 0, no input of lift curve slope

IFCLCS = 1, input effective lift curve slope

IAGC = Automatic gain control flag.

IACG = 0, automatic gain control disabled.

IACG = 1, automatic gain control enabled.

FALIM = Fin angle limit for Automatic Gain Control.

FVLIM = Fin angle velocity limit for Automatic Gain Control.

RECORD 9B - required if NFNSET > 0 and IACTFN > 0

(FAREDUCT(IV),IV=1,NVK) (8f10.4)

where

FAREDUCT = Array of speed dependent reduction factors applied to the fin angle limit for Automatic Gain Control. (nondimensional, one for each specified speed)

RECORD 9C - required if NFNSET > 0 and IACTFN > 0

(FGAIN(IV),IV=1,NVK) (8f10.4)

where FGAIN = Array of speed dependent fin fixed gain factors (nondimensional, one for each specified speed)

RECORD 9D - required if NFNSET > 0 and IACTFN > 0

(FK(I),I=1,3) (8f10.4)

where FK = Array of fin controller coefficients, where FK(1) is proportional to roll angle, FK(2) is proportional to roll velocity, and FK(3) is proportional to roll acceleration

RECORD 9E - required if NFNSET > 0 and IACTFN > 0

(FA(I),I=1,3) (8f10.4)

where FA = Array of fin servo coefficients.

RECORD 9F - required if NFNSET > 0 and IACTFN > 0

(FB(I),I=1,3) (8f10.4)

where FB = Array of fin controller compensation coefficients.

RECORD 9G - NFNSET records required if NFNSET > 0 and IFCLCS > 0

(FCLCS(IV,K),IV=1,NVK) (8f10.4)

where FCLCS = Array of speed dependent effective fin lift curve slopes for each fin set. (one for each specified speed).

RECORD 9H - NFNSET pairs of records required if NFNSET > 0

RECORD h.1: Specify root of fin FNRFS,FNRAS,FNRHB,FNRFWL,FNRAWL (5f10.4)
where: FNRFS = forward station of root of fin set.

FNRAS = aft station of root of fin set.

FNRHB = y coordinate, positive, of root of fin set.

FNRFWL= z-coordinate, positive up from baseline, of forward station of root.

FNRAWL= z-coordinate, positive up from baseline, of aft station of root.

RECORD h.2: Specify tip of fin FNTFS,FNTAS,FNTHB,FNTFWL,FNTAWL (5f10.4)
where: FNTFS = forward station of tip of fin set.

FNTAS = aft station of tip of fin set.

FNTHB = y-coordinate, positive, of tip of finset.

FNTFWL= z-coordinate, positive up from baseline, of forward station of tip.

FNTAWL= z-coordinate, positive up from baseline, of aft station of tip.

Record Set 10: Skeg

Offsets describing the skeg are required in Record Set 6.

Record 1 – FORMAT (15)

[NSKSET] (Integer) – column 5, number of sets of skegs (maximum of two sets allowed).

NEXT RECORD REPEATED FOR EACH SKEG SET, SKIP IF NSKSET=O.

Record 2 – FORMAT (7F10.4)

[SRFLS] (Real) – columns 1-10, forward station of this skeg set.

[SRALS] (Real) – columns 11-20, aft station of this skeg set (bottom of skeg).

[SRAUS] (Real) – columns 21-30, aft station of this skeg set (top of skeg).

[SKHB] (Real) – columns 31-40, y-coordinate of skeg set (zero for a skeg on the centerline, see Figure 4-4b).

[SRFLWL] (Real) – columns 41-50, z-coordinate of the forward station of the skeg set (positive up from baseline).

[SRALWL] (Real) – columns 51-60, z-coordinate of aft station (bottom) of skeg set.

[SRAUWL] (Real) – columns 61-70, z-coordinate of aft station (top) of skeg set.

For each skeg set, this record uniquely defines the x, y, z hull coordinates for the forward, top aft, and bottom aft centerline of the skeg. (See Figure 4-4a).

Record Set 11: Propeller Shaft Particulars

RECORD 11A - always required:

NPSSET I5

Number of propeller shaft sets

RECORD 11B - NPSSET required if NPSSET > 0:

IPSPR,PSDIA,PSFST,PSAST,PSFWL,PSAHB,PSAHB,PSAWL I5,7F10.4

IPSPR - index of associated propeller

PSDIA - propeller shaft diameter

PSFST - station, half breadth, and waterline of forward end of shaft segmentPSAST - station, half breadth, and waterline of forward end of shaft segmentPSFWL - station, half breadth, and waterline of forward end of shaft segment

PSAHB - station, half breadth, and waterline of after end of shaft segmentPSAHB - station, half breadth, and waterline of after end of shaft segmentPSAWL - station, half breadth, and waterline of after end of shaft segment

Record Set 12: Shaft Brackets – See Fig. 4-6.

Record 1 – FORMAT (15)

[NSBSET] (Integer) – column 5, number of sets of propeller shaft brackets (maximum of two allowed).

NEXT TWO RECORDS REQUIRED FOR EACH BRACKET SET, SKIP IF NSBSET=0.

Record 2 – FORMAT (5F10.4)

[SOBRFS] (Real) – columns 1-10, forward station of outside root of bracket set.

[SOBRAS] (Real) – columns 11-20, aft station of outside root of bracket set.

[SOBRHB] (Real) – columns 21-30, y-coordinate (positive) of outside root of bracket set.

[SOBRFW] (Real) – columns 31-40, z-coordinate (positive up) of forward station of root.

[SOBRAW] (Real) – columns 41-50, z-coordinate of aft station of root.

Record 3 – FORMAT (5R10.4)

[SMTFS] (Real) – columns 1-10, forward station of tip of bracket set.

[SBTAS] (Real) – columns 11-20, aft station of tip.

[SBTHB] (Real) – columns 21-30, y-coordinate of tip.

[SBTFWL] (Real) – columns 31-40, z-coordinate of forward station of tip.

[SBTAWL] (Real) – columns 41-50, z-coordinate of aft station of tip.

Record Set 13: Propeller Particulars

RECORD 13A - always required: NPRSET I5 Number of propeller sets
RECORD SET 13B - required NPRSET times if NPRSET > 0: Line 1:

PRST(IS), PRHB(IS), PRWL(IS), PDIAM(IS) ,TDC(IS), WAKET(IS), WAKEQ(IS), PSRATIO(IS)

8F10.4

PRST(IS) Station of the propeller shaft axis

PRHB(IS) halfbreadth of the propeller shaft axis

PRWL(IS) waterline of the propeller shaft axis

PDIAM(IS) propeller diameter

TDC(IS) (i-t)

WAKET(IS) (1-w_t)

WAKEQ(IS) (1-w_q)

PSRATIO(IS) ratio of speed of this shaft set to reference shaft set. (relevant only if NRRSET > 1, should be one otherwise) If prhb .ne. 0, it is assumed that there is a pair of propellers equally spaced on either side of the centerline. (This convention is similar to that for the rudder)

Line 2:

(ckt(i,is),i=1,3),(ckq(i,is),i=1,3) 6F10.4

coefficients for parabolic fits to the K_T and K_Q curves,

K_T = ckt(1,is) + ckt(2,is) J + ckt(3,is) J^2

RECORD b - required once if NPRSET > 0:

IRNFLG,NRESC 2I5

IRNFLG is a flag for resistance data or propeller rps data

Number of froude numbers for which resistance or rps data is provided For IRNFLG = 1, the following records are required, one pair per line

(FNRESC(i),CTOTAL(i),i=1,NRESC) F10.4,F15.9

Froude number and corresponding total resistance coefficient

For IRNFLG = 2, the following records are required, one set per line

((FNRESC(i),NRPSRI(j,i),j=1,NPRSET),i=1,NRESC)

F10.4,F15.9

NRPSRI are per propeller set. The froude number range input must exceed the required range, as spline interpolation is performed to obtain the shaft speed at the required ship speeds.

Record Set 14: Rudder

Record 1 – FORMAT (I5)

[NRDSET] (Integer) – column 5, number of sets of rudders (maximum of two sets allowed).

NEXT TWO RECORDS REQUIRED FOR EACH RUDDER SET, SKIP IF NRDSET=O.

Record 2 – FORMAT (5F10.4)

[RDRFS] (Real) – columns 1-10, forward station of root of rudder set.

[RDRAS] (Real) – columns 11-20, aft station of root of rudder set.

[RDRHB] (Real) – columns 21-30, y-coordinate (positive) of root of rudder set (see Figure 4-5b).

[RDRFWL] (Real) – columns 31-40, z-coordinate (positive up from baseline) of forward station of root.

[RDRAWL] (Real) – columns 41-50, z-coordinate of aft station of root.

Record 3 – FORMAT (5F10.4)

[RDTFS] (Real) – columns 1-10, forward station of tip.

[RDTAS] (Real) – columns 11-20, aft station of tip

[RDTHB] (Real) – columns 21-30, y-coordinate of tip (see Figure 4-5b).

[RDTFWL] (Real) – columns 31-40, z-coordinate of forward station of tip.

[RDTAWL] (Real) – columns 41-50, z-coordinate of aft station of tip.

For each rudder set, the above records define the coordinates of the root and tip centerline of rudder (see Figure 4-5a).

Record Set 15: Passive Stabilizers

RECORD 1: NPSTBS = the number of passive stabilizers (integer, list I/O).

If NPSTBS= zero, no further input is required, and all the stabilizer code will be inoperative.

Under current dimensioning, up to three passive stabilizers may be specified, (NPSTBS greater than three is fatal error.)

If NPSTBS .ne. 0 then NPSTBS more "records" of input to define each of the NPSTBS stabilizers are required.

"RECORD 2" through "RECORD NPSTBS+1", each require 13 input numbers.

The read statement for each "record" is list I/O. Thus, the 13 numbers may be continued on multiple lines as long as no comments intervene. Comments before and after each "record" are permitted. Typically, all 13 numbers, to reasonable significance, will fit within the required 80 columns.

The variable names for each stabilizer definition are, in order:

NSTBNO, NSTBTP, NSTBUN, XSTB, GAMST, WPINER, OMSTB, RSC1, RSC2,

BSTBL, BSTBQ, RPSTAB, SATSTB

(The first three are integer, the remaining 10 are real.)

A brief definition of each of the variables follows:

NSTBNO= An arbitrary stabilizer identification number, limit to three digits for formatting reasons.

NSTBTP= The stabilizer type: 1=U-tube, 2=Free-surface tank, 3=moving weight.

NSTBUN– A unit flag: 0=following dimensional variables are input in feet,

1=input in meters.

Note that the definition of length units MUST be the same as that for the ship in earlier input.

XSTB= Longitudinal location of stabilizer, feet or meters, positive aft of FP.

GAMST= Stabilizer types 1 and 2: specific gravity of tank fluid relative to that of the sea or fresh water specified in Record Set 3.

For fresh water in the tank and the ship in sea water, GAMST is

approximately = 62.4/64=0.975. For tanks, the mass density of the fluid is computed as GAMST*RHO. Stabilizer type 3: use GAMST = 1.0 (see discussion of WPINER).WPINER= Stabilizer types 1 and 2: the transverse waterplane inertia of the tank liquid (feet**4 or m**4). NOTE: DO NOT include the corresponding free surface correction to GMT in the earlier input, the dynamic solution takes care of it.

Stabilizer type 3: the volume of sea water equivalent to the mass of the moving weight (feet**3 or m**3); that is, the mass of the moving weight is computed internally asRHO*GAMST*WPINER.

OMSTB= The stabilizer natural frequency, rad/sec.

RSC1,RSC2= The variables RSC1 and RSC2 between them define the effective vertical location of the stabilizer relative to the vertical CG of the ship. Internally this height is computed as RSC1-RSC2*KG, with KG found later from the other inputs for the ship. Units of RSC1 are feet or meters, RSC2 is non-dimensional.

For stabilizer type 1: RSC1-RSC2*KG = S"/2, half the classical coupling length.

For stabilizer type 2: RSC1=(distance of tank bottom above keel + half the water depth), RSC2=1.0.

For stabilizer type 3: RSC1 = distance of weight above keel, RSC2=1.0.BSTBL= Empirical linear stabilizer damping coefficient, fraction of critical.

BSTBQ= Empirical nondimensional quadratic stabilizer damping coefficient. Definition varies somewhat with stabilizer type, see the background section.

NOTE: either, but not both, of the damping coefficients may be zero.

RPSTAB= Stabilizer types 1 and 2: transverse offset of center of wing tank. (feet or meters). Used to define the location of the vertical motion of the tank fluid which is used as the dynamic tank variable. Stabilizer type 3: use RPSTAB=1.0, since not applicable.

SATSTB= Saturation limit definition (feet or meters). For stabilizer types 1 and 2, the distance above or below the static tank waterline, at the lateral offset defined by RPSTAB, where saturation is expected to begin.

For stabilizer type 3, the limit of transverse motion of the weight.

Record Set 16: Sinkage and Trim

STOPTN I5 Sinkage and trim option. Allowable values are:

0 none. Bishop and Bales approximation for destroyer hulls (existing SMP option)1 input data

If STOPTN = 1 then the following need to be read in:RECORD SET 16.1 nstri I5 do i = 1,nstri

fnstri(i),snkri(i),trmri(i) 3F10.5

enddo

FNSTRI is the froude number, SNKRI is the sinkage in PUNITS at midships, positive down, and TRMRI is the trim, measured in PUNITS as the difference between the bow and stern sinkage, positive bow up.

These values are interpolated over speed and consequently do not need to be changes as requested speeds are changes. They must be in ascending order of Froude number and should cover the entire speed range requested.

Record Set 17: Wave Profile

WPOPTN I5 - Wave profile option. Allowable values are:

0 existing smp model (none)

1 input data

2 Bishop and Bales approximation for destroyer hulls

If WPOPTN = 1 then the following need to be read in:

RECORD SET 17.1

nwprifn,nwprist 2I5

NWPRIFN Number of froude nos for wave profile input

NWPRIST Number of stations for wave profile input

```
do i = 1,nwprifn
  do j = 1,nwprist
    fnwpri(i),stwpri(j,i),wprzri(j,i) 3F10.5
  enddo
 enddo
```

FNWPRI Froude number

STWPRI station may vary with speed

WPRZRI wave elevation, in PUNITS, positive up

These values are interpolated over speed and consequently do not need to be changes as requested speeds are changes. They must be in ascending order of Froude number and should cover the entire speed range requested. Outside the range of stwpri, the wave profile is assumed to be zero. The station values should be in ascending order. For best results, the wave profile at the first and last stations should be zero. The stations at which the wave profile values are given need not be at exactly the desired deck wetness calculation stations. Note that the range of stations may vary with speed, but the number of stations must be the same for all stations. Note also that the stations as well as the elevations are interpolated over speed using splines, the values should vary smoothly.

Record Set 18: Roll Damping Model Selection

For development only

Record Set 19: Stop

Record 1 – FORMAT (A4)

[STOP] (Character) – columns 1-4, type STOP (last record to be read).

13.2 SMP95 Monohull Irregular Wave Module Input File Description

13.2.1 SMP Monohull Irregular Wave Input Record Overview

This section gives further information on the data that is entered in the Regular Wave input file. In VisualSMP, this data is entered through dialogs as described in Section 4. However, the ASCII file may be edited by hand (carefully), with data described here.

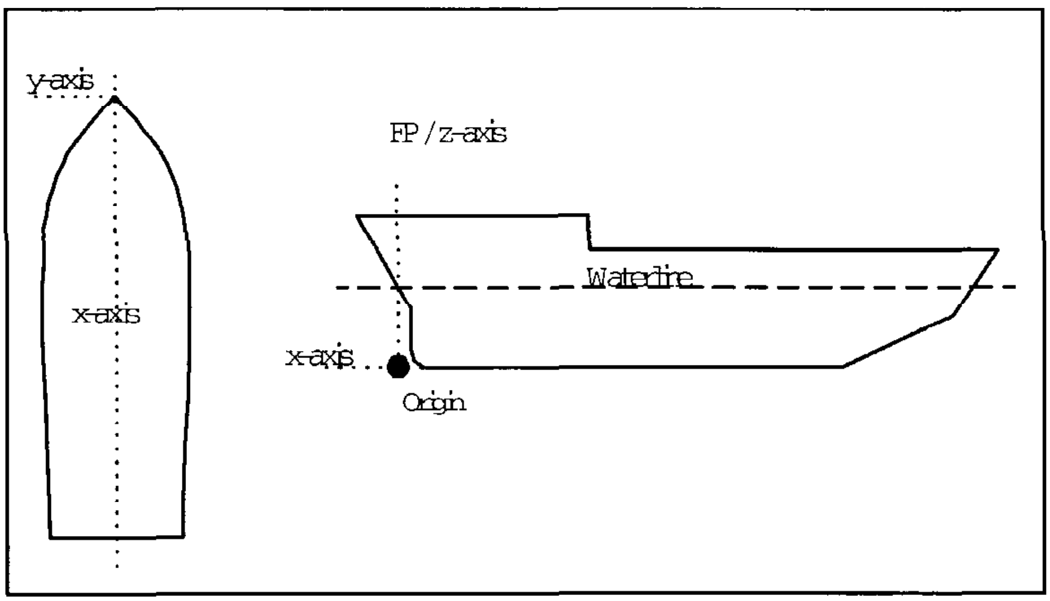
The input to be developed for the irregular wave module consists of seaway definitions and point locations for motion calculations. The data is made up of data record sets. The number of data record sets required for the irregular wave module is 8; however, the number of records within each set will vary according to the individual ship particulars and user requirements. Table 1-1 summarizes the 8 data record sets.

Table 1-1: Record Set Summary

Record Set	Definition
1	Title
2	Program Options
3	Statistic Used for Roll Iteration
4	Seaway Description
5	Motions at a Point
6	Relative Motions
7	Ship Response
8	STOP

Users should be aware that when using fixed file formats, integers must be keyed at the correct location, i.e., right justified within their specified fields. Floating point (real) numbers and character information may be placed anywhere within the specified fields (unless otherwise indicated in the data record sets).

The reference system, which is used for input data to SMP is illustrated in Figure 1-1. The origin (station 0) for this system is defined as the intersection of the ship's forward perpendicular, centerline and baseline. Station 20.0 is defined at the aft perpendicular. The y-coordinate of this system is measured from the ship's centerline with y positive to port. The z-coordinate of this system is measured from the ship's baseline with z positive up. The units of y and z must be the same, but can be expressed in either feet or meters.



This reference system is used to define the input values for the underwater hull geometry, hull and loading particulars, appendage information, and point locations at which motions are computed. Units for the irregular wave input file must be consistent with those found in the regular wave file.

13.2.2 Record Set Description

This particular section on the description of the record sets is an illustrative formulation on how to prepare an regular wave input file. It is an important section to which the user should constantly refer before running a ship through regular wave module. Thus, careful reading of this section is highly recommended.

Note that each data record set is made up of one or more records. Any specific data record set that should not be used is represented by a blank record. It should also be noted that some records within a data record set may be eliminated or skipped, depending on the user's needs and information. The method used to describe each data record set is to list each record, its FORTRAN format, and the variable(s) contained on it.

RECORD SET 1 TITLE

Variable: TITLE

Format: 20A4

RECORD SET 2 - OPTIONS

Variables: RAOPRNOPTN, LRAOPRNOPTN, RSVPRNOPTN, SEVPRNOPTN, LCOPTN, SCOPTN, TOEOPTN

Format: 10I5

Define as 1 to activate option, 0 otherwise

RAOPRNOPTN: Option to print ship response amplitude operators,

LRAOPRNOPTN: Option to print load response amplitude operators,

RSVPRNOPTN: Option to print ship response statistical values,

VLACPR: Option to print RMS velocities and accelerations

SEVPRNOPTN: Option to print severe motion table (If = 1, severe motion tables are printed under the same conditions as for SMP84.)

LCOPTN: Option to select longcrested seas

SCOPTN: Option to select shortcrested seas

TOEOPTN: Option to select encountered modal periods (TOEs) for all responses

RECORD SET 3 - STATISTIC USED FOR ROLL ITERATION

Variables: STATIS, (STATNM(I),I=1,5)

Format: F10.4, 5A4

STATIS: Value used in calculation of responses to irregular waves: multiplies RMS value

(STATNM(I),I=1,5): label If STATIS is input as less than or equal to 0, the following default values are used:

STATIS = 2.00

STATNM(I) = 'SIGN','IF. ','SA ',' ',' '

RECORD SET 4 - SEAWAY DESCRIPTION

RECORD SET 4a:

Variables: IWVSPC, GAMMA

Format: I5, F10.4

IWVSPC: 0 for Bretschneider wave spectrum

1 for Jonswap wave spectrum

GAMMA: Peak factor for Jonswap wave spectrum; 0 for Bretschneider Value is forced to be between 1 and 4. (If it is less than 1, it will be redefined to be 1; if greater than 4, it will be redefined to be 4.)

RECORD SET 4b: Input number of significant wave heights. Must be no greater than mxnsigwh which is defined in the param.def file, currently as 20.

Variable: NSIGWH

Format: I5

NSIGWH: number of significant wave heights (Default value: 4)

RECORD SET 4c: Input significant wave heights.

Variable: (SIGWH(K),K=1,NSIGWH)

Format: 8F10.4

SIGWH: Significant wave height.

DEFAULT VALUES:

IF the roll period is greater than 15 sec, the following significant wave heights, in meters, correspond to Sea States 4, 5, 6, and 7:

SIGWH(1) = 2.0

SIGWH(2) = 3.0

SIGWH(3) = 5.0

SIGWH(4) = 7.5

IF the roll period is less than or equal to 15 seconds and greater than 9 seconds, the following definitions, in meters, correspond to Sea States 3, 4, 5, and 6:

SIGWH(1) = 1.5

SIGWH(2) = 2.0

SIGWH(3) = 3.0

SIGWH(4) = 5.0

Otherwise, the values which correspond to Sea States 2, 3, 4, and 5 are:

SIGWH(1) = 1.0

SIGWH(2) = 1.5

SIGWH(3) = 2.0

SIGWH(4) = 3.0

RECORD SET 4d: Input number of modal wave periods. Must be no greater than mxntmod which is defined in the param.def file, currently as 15.

Variable: NTMOD

Format: I5

NTMOD: Number of modal periods (Default: 8)

RECORD SET 4e: Input modal wave periods

Variable: (TMODAL(K),K=1,NTMOD)

Format: 8F10.4

TMODAL: modal period of wave spectrum, in seconds.

DEFAULT VALUES:

starts with a minimum value, based on natural roll period, and increases in increments of 2 sec.

IF the roll period is greater than 15 sec, the first modal period is 7 sec;

IF the roll period is less than or equal to 15 seconds and greater than 9 seconds, the first modal period is defined as 5 seconds; otherwise, the first modal period is 3 seconds.

RECORD SET 5 - MOTIONS AT A POINT

RECORD SET 5a: Input number of points where absolute motions will be calculated. Must be no greater than mxnptloc which is defined in the param.def file, currently as 10.

Variable: NPTLOC

Format: I5

RECORD SET 5b - Input labels and point locations - include if NPTLOC defined in Record Set 5a is greater than 0.

For the Kth of NPTLOC points, define:

Variable: PTNUMB(K), (PTNAME(I,K),I=1,8), XPTLOC(K), YPTLOC(K), ZPTLOC(K)

Format: I5,5X,8A4,8X,3F10.4

PTNUMB(K): integer used for label only, typically point location number(PTNAME(I,K),I=1,8): identifying label used in output

XPTLOC(K): x coordinate: station number, based on 20 stations.

YPTLOC(K): y coordinate: ship centerline is 0, positive to port

ZPTLOC(K): z coordinate: from baseline (with waterline at DBLWL)

RECORD SET 6 - RELATIVE MOTION

RECORD SET 6a: Input number of points where relative motions will be calculated. Must be no greater than mxnfrebd which is defined in the param.def file, currently as 10.

Variable: NFREBD

Format: 2I5

NFREBD: number of points where relative motion (and related responses) are to be calculated

RECORD SET 6b - Input labels and point locations - include if NFREBD defined in Record Set 6a is greater than 0.

For the Kth of NFREBD points, define:

Variable: FBNUMB(K), (FBNAME(I,K),I=1,8), XPTFBD(K), YPTFBD(K), ZPTFBD(K)

Format: I5,5X,8A4,8X,3F10.4

FBNUMB(K): integer used for label only, typically point location number

(FBNAME(I,K),I=1,8): identifying label used in output

XPTFBD(K): x coordinate: station number, based on 20 stations.

YPTFBD(K): y coordinate: ship centerline is 0, positive to port

ZPTFBD(K): z coordinate: from baseline (with waterline at DBLWL)

RECORD SET 7 - SHIP RESPONSES

RECORD SET 7a: Origin Motions - Always include

Variable: (ORGRSP(I),I=1,3)

Format: (3I5)

Define as 1 to activate option, 11 to activate motion and Toes; 0 otherwise.

NOTE: three components will be calculated in each case.

ORGRSP(1): DSP - Displacement for 6DOF responses

ORGRSP(2): VEL - Velocity " " "

ORGRSP(3): ACC - Acceleration " " "

RECORD SET 7b: Include if NPTLOC defined in Record Set 5a is greater than 0,

For the Kth of NPTLOC points, define:

Variable: (PTRSP(I,K),I=1,9)

Format: 9I5

Define as 1 to activate option, 11 to activate motion and Toes; 0 otherwise.

For responses at the Kth point location specified in Record Set 5b

PTRSP(1,K): DSP - Displacement for translations in x, y and z directions

PTRSP(2,K): VEL - Velocity for translations in x, y and z directions

PTRSP(3,K): ACC - Acceleration for translations in x, y and z directions

PTRSP(4,K): HFE - Longitudinal and lateral accelerations in the body axis (Ship) coordinate system

PTRSP(5,K): MSI - Motion Sickness Incidence (not completely implemented)

PTRSP(6,K): SLD - Motion Interruption induced by sliding (not completely implemented)

PTRSP(7,K): TIP - Motion Interruption induced by tipping (not completely implemented)

RECORD SET 7c: Include if PTRSP(6,K) or PTRSP(7,K) in Record Set 7b is non-zero (i.e., sliding or tipping)

Variable: objcg, xmu

Format: 2F10.4

objcg: CG of object/person relative to ZPTLOC(K) Used in tipping and sliding calculations. [Default = 3 feet]

xmu: coefficient of friction for sliding Must be between 0 and 1. [Default value = 0.25]

RECORD SET 7d: Include if NFREBD defined in Record Set 6a is greater than 0,

For the Kth of the NFREBD points, define:

Variable: (RMRSP(I,K),I=1,5)

Format: 5I5

Define as 1 to activate option, 11 to activate motion and Toes;

0 otherwise

For responses at the Kth point location specified in Record Set 6b

RMRSP(1,K): DSP - Relative Motion displacement

RMRSP(2,K): VEL - Relative Velocity

RMRSP(3,K): SLM - Slamming

RMRSP(4,K): EMG - Propeller tip emergence

RMRSP(5,K): WET - Wetness

RMRSP(6,K): SPR - Slam pressures

RMRSP(7,K): SFR - Slam forces

RECORD SET 7e: Include if RMRSP(6,K) > 0 or RMRSP(7,K) > 0 (slam pressures or slam forces),

Note: the "slam force" code is included to preserve it; its validity needs to be established.

Line 1:

Variables: K, HWB(K), DRANGL(K), ALPHA(K), HRS(K)

Format: I10, 5F10.5

K

HWB - half width of flat bottom at station

DRANGL - deadrise angle in degrees at station if drangl < or = 0 - ochi's method used to compute form factor if drangl > 0 - truncated wedge method used to compute form factor

ALPHA - exceedance parameter for calculation of extreme slamming pressure for design consideration

SDRAFT - design draft or draft at station depending on who you believe (ochi and motter or schmitke)

HRS - number of hours of ship operation time

Note: if K is not correct, program stops

If Ochi-Motter method used to compute the form factor, the following data must be provided, starting at the keel or at the edge of the flat bottom. The vertical extent must equal or exceed ten percent of the local draft. The input format is the same as that for hull section input. Knuckles are allowed. This section data will be interpolated to obtain section data at the exact waterlines required by the Ochi-Motter method

Line 2:

Variables: STASLM, NP, KFS

Format: F10.4, 2I5

STASLM - Station for slam pressure section data

NP - Number of points on station

KFS - Flag = 1 to indicate knuckles on station, 0 otherwise

Line 3:

Variables: STASLM, (HLFBSL(J),J=1,NP)

Format: F10.4,10F7.2

STASLM - Station for slam pressure section data

HLFBSL(J) - Halfbreadths of section points

Line 4:

Variables: STASLM, (WTRLSL(J),J=1,NP)

Format: F10.4, 10F7.2

STASLM - Station for slam pressure section data

WTRLSL(J) - Waterlines of section points

Line 5:

Variables: (KSL(J),J=1,NP)

Format: 10x, 10(6X,I1)

KSL(J) - Flags = 1 to indicate knuckles at this point, 0 otherwise

RECORD SET 7e: Load Responses at load stations specified in the SMPREGW input file

Variable: (LDRSP(I),I=1,5)

Format: 5I5

Define as 1 to activate option, 11 to activate motion and Toes; 0 otherwise

LDRSP(1): HSF - Horizontal Shear Force

LDRSP(2): VSF - Vertical Shear Force

LDRSP(3): TRM - Torsional Moment

LDRSP(4): HBM - Horizontal Bending Moment

LDRSP(5): VBM - Vertical Bending Moment

RECORD SET 8 - STOP

Variable: STOP

Format: (20A4)

Define as 'STOP'.

13.3 SMP95 Passive Stabilizer Option

13.3.1 OBJECTIVE

The objective of the passive stabilizer option in SMP95 is to enable some approximate estimates of the worth, or otherwise, of passive ship stabilization. The caveat arises because even the simplified practical models of the dynamics of the most used tank stabilizer types contain two types of (not entirely negligible) nonlinearities. The first type of nonlinearity is "quadratic" tank damping. The second type is that of the eventual saturation of the roll moment generation capability for large tank excitations. These nonlinearities have to be handled in an approximate way within the limitations imposed by the linearized frequency domain method of SMP.

13.3.2 RANGE OF STABILIZER TYPES

The analytical models of both common forms of passive tanks, as well as that of a moving weight stabilizer, are ultimately of identical form. Consequently, as long as some variation in the definition of the input parameters are allowed, the same basic code can serve to represent the effects of U-tube tanks, Free-surface tanks, and moving weight stabilizers.

13.3.3 APPROACH TO THE HYDROMECHANICAL SOLUTION

The way in which SMP handles the basic ship roll nonlinearities determines to a great degree how the passive stabilizer solution is handled. The basic SMP theory holds that the ship roll nonlinearities are *purely* a function of roll amplitude. Given this assumption, the SMP way is to linearize the lateral motion solution for each of a number of *assumed* roll amplitudes, thus producing a number of sets of lateral motion transfer functions, each of which is associated with the assumed roll amplitude. Predictions of lateral motions in irregular seas are made by an interpolation procedure where the interpolation point is determined by an equality of interpolated assumed roll amplitudes with interpolated significant roll amplitudes which are predicted from the corresponding set of linearized transfer functions.

The present approach to the solution of the coupled nonlinear ship-stabilizer dynamics is conceptually similar to that adopted for free-flooding tanks some years ago[1]. Each combination of ship sped, heading, assumed roll angle and wave frequency defines a deterministic problem which may be handled in the frequency domain. Each frequency domain solution for a point of the stabilized roll transfer function is made iteratively in two stages, the first to obtain a solution for an unsaturated stabilizer, and the second to correct for the effects of saturation.

At the start of each iteration for the unsaturated stabilizer an estimate of the roll and stabilizer transfer functions are in hand, either by guessing, or from previous iterations. The fact that a fixed, constant, roll amplitude was assumed in the first place allows and *implied* wave amplitude to be computed. With an implied wave amplitude and the estimate of the tank motion transfer function, an estimate of stabilizer amplitude may be obtained. With the stabilizer amplitude, the nonlinearities may be evaluated and linearized to complete the specification of a linearized coupled ship-stabilizer problem which has one extra degree of freedom for each stabilizer. Solution of the coupled problem yields revised estimates of roll and stabilizer transfer functions, which are used to begin the iteration again, unless the solutions differ form the initial assumptions by a small enough amount to ignore.

Once a reasonably good solution is obtained for the unsaturated case, the implied wave amplitude is used to compute the stabilizer motion, and the answer is compared with the specified saturation limits. If the stabilizer motion is not within the specified saturation limits, a second iteration, generally similar to the first, is carried out. In this second iteration the stabilizer amplitudes exceeding the saturation limit are limited to a reasonable level by a conventional energy argument. Once stabilizer amplitude is limited, the solution for the stabilizer transfer function is known. With a known stabilizer solution, the saturated stabilizer degree of freedom is dropped from the coupled ship-stabilizer problem, and corresponding stabilizer coupling terms formerly on the left hand side of the system of linearized motion equations are transposed to the right hand side to correct the motion excitation for the effects of the saturated stabilizer.

It should be noted that this approach to the production of stabilized roll transfer functions involves approximating the nonlinear solutions to a physical problem where the amplitude of the exciting regular wave is *adjusted* so as to produce a stabilized roll amplitude which is essentially equal to that assumed. Though it fits with the SMP way of doing things, the result for a single assumed roll amplitude is not the same as would be obtained form a physical regular wave test results requires an interpolation procedure similar to that adopted by SMP for irregular waves.

13.3.4 IRREGULAR WAVE PREDICTIONS

Once the hydromechanical problem is solved, the resulting lateral motion transfer functions are stored and used in exactly the same way as in the unstabilized case. Consequently, apart from the transfer functions, and answers, will be different from the unstabilized case, none of the down-stream SMP processing for motions in irregular waves is affected by the presence of stabilizers.

A by-product of the solution is a set of stabilizer motion transfer functions for the unsaturated case. The only really useful thing which can be done with these results is to predict the number of saturations per unit time. This operation is carried out in the irregular wave half of SMP95, and the results are listed for the most saturated stabilizer in the more-or less standard SMP way for slamming or deck wetness incidence. The saturation incidence results are listed automatically as long as the user does not suppress the listings of the basic ship motion responses.

13.3.5 TANK STABILIZERS

As has been noted, the basic equations are identical for the two common types of tank stabilizers. The equation for either type of stabilizer ends up in the program in the following form:

$$\rho\gamma I_W \ddot{\xi}_2 + \rho\gamma I_W [g\xi_4 - \ell\ddot{\xi}_4] + \rho\gamma I_W \bar{X}\ddot{\xi}_6 +$$

$$\frac{\rho\gamma g I_W}{\Re}\left[\frac{\ddot{\xi}_7}{\omega_t^2} + \xi_7\right] + \frac{2\rho\gamma g I_W}{\Re\omega_t}\beta_L\dot{\xi}_7 + \frac{\rho\gamma I_W}{\Re}\beta_Q|\dot{\xi}_7|\dot{\xi}_7 = 0 \qquad (1)$$

where the first three terms are the transposed excitation to the tank and:

ξ_2 is the sway motion,

ξ_4 is the roll motion,

ξ_6 is the yaw motion, and

ξ_7 is the tank fluid motion measure. Tank motion is defined as a vertical motion of the tank free surface in a wing tank. The exact lateral location is defined by the parameter $\Re$.

$\Re$ is the lateral offset of the location of the "measurement" of ξ_7.

$\rho\gamma$ represents the mass density of the fluid in the tank, in terms of ρ, the mass density of the water in which the ship floats, and γ, a specific gravity of the fluid in the tank relative to ρ.

g is the gravitational constant.

I_W is the transverse inertia about the ship centerplane of the tank waterplane area.

$\bar{X}$ is the longitudinal location of the tank with respect to the ship vertical center of gravity.

ℓ is the effective vertical location of the tank relative to the ship vertical center of gravity.

ω_t is the tank natural frequency (rad/sec).

β_L is a nondimensional linear damping coefficient.

β_Q is a nondimensional quadratic damping coefficient.

Equation 1 expresses the moment response of the tank in response to moment excitation produced by the motion of the ship. As defined above, the units of each of the terms in Eq. 1 are moment (about the center of gravity of the ship). Within the program, all the motions are implicitly divided by wave amplitude because of the necessity of computing transfer functions, and the actual equation within the program has units of force.

Unfortunately, the fluid dynamics internal to the tank are sufficiently complicated that, for serious design, the tank frequency and damping coefficients, ω_t, β_L, and β_Q, are regarded as empirical parameters which must be obtained from bench tests of model tanks.

The tank frequency, ω_t is taken from bench tests as the frequency of peak tank motion response for very small excitation, or, as the frequency at which the moment response of the tank lags motion by 90°.

The definition of the damping coefficients may be better illustrated by writing the equation for the tank dynamics after an impulsive excitation (a viable experimental approach for U-tubes at least). Zeroing the first three excitation terms of Eq. 1, and eliminating common factors results in an equation for ξ_7, partially in the standard form of a simple oscillator:

$$\ddot{\xi}_7 + \omega_t^2 \xi_7 + 2\omega_t \beta_L \dot{\xi}_7 + \frac{\omega_t^2}{g} \beta_Q \left|\dot{\xi}_7\right| \xi_7 = 0 \qquad (2)$$

From Eq. 2 the coefficients of the linear damping of the tank motion immediately identify β_L as a fraction of critical damping. Similarly, the non-dimensional quadratic damping of the tank motion, β_Q, would be a fitted empirical dimensional coefficient (units of 1/length) times g/ω_t^2.

13.3.5.1 Particular input parameter definitions, U-tube stabilizer

The detail and form of the general equation for the tank, Eq. 1 owes much to the early work of Webster[2,3] for U-tubes. Equation 1 is essentially that of Webster, after compensating for the fact that the SMP coordinate system has the Z-axis positive up instead of down, and transforming Webster's "tank angle", τ, to vertical motion at the wing tank center by $\xi_7 = \Re\tau$. A few of the parameters defined for Eq. 1 have special definitions for the U-tube as follows:

I_W is conventionally taken to be $2A_0R^2$ where A_0 is the area of the free surface in one wing tank.

ℓ is half the classical coupling length, S^{11}, defined for example by Webster[3]. That is, in Eq. 1, $\ell = S^{11}/2$.

ω_t is defined by $\omega_t = \sqrt{2g/S^1}$, where S^1 is the classical effective U-tube length[3].

13.3.5.2 Some approximations for U-tube tank input

On the premise that first approximations may be useful, and/or, that no bench test results are available for a U-tube tank similar to a candidate U-tube geometry, a pre-processor program named *UTTANK* was developed to ease the production of preliminary U-tube input to SMP95. Such a thing is possible only the simplified tank geometry. The simplified geometry assumed is indicated in Fig. 1 where the upper diagram is of athwartship section through the tank, and the lower is the planform.

U-Tube Anti-Roll Tank

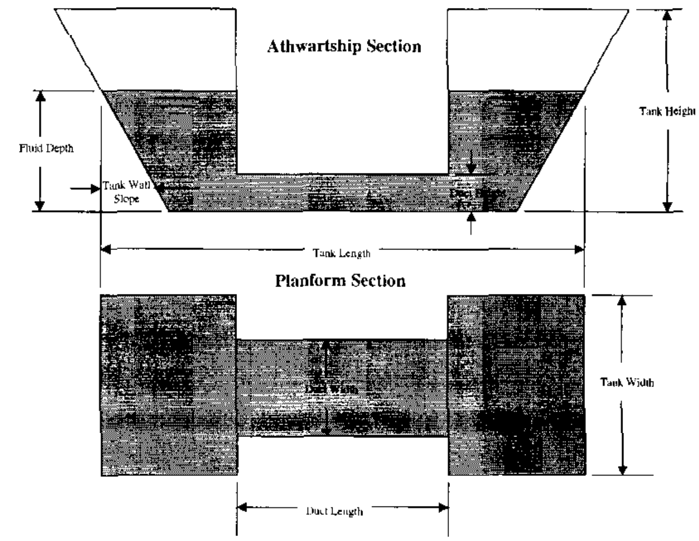


Fig. 1. Terminology, simplified U-tube Tank

As shown in the figure, the simplified geometry involves a rectangular crossover duct B_c in length, D_c in height and L_c in width. The wing tanks, of width L_t (fore and aft direction), are allowed to flare α degrees, and the overall thwartship tank length, B_t, is reckoned to the intersections of the static waterline with the outboard sides of the wing tanks. The static water depth is denoted by *h*.

With the geometry shown in Fig. 1:

$$A_o = L_t(B_t - B_c)/2$$

$$\Re = (B_t + B_c)/4$$

$$S^1 \approx \frac{A_0 B_c}{D_c L_c} + 2h\left[\frac{-\ln\left\{1 - \frac{2h}{(B_t - B_c)}\tan(\alpha)\right\}}{\frac{2h}{(B_t - B_c)}\tan(\alpha)}\right]$$

$$S^{11}\big/2 \approx Z_0 + h - (h - D_c/2)\left[2 - \frac{(h - D_c/2)}{\Re}\tan(\alpha/2)\right] - \overline{KG}$$

where Z_0 is the distance form keel to the tank bottom, and $\overline{KG}$ is the ship vertical center of gravity.

With the previous definitions of geometric parameter and tank frequency, the above leaves the nondimensional damping coefficients, β_L and β_Q to be defined. The UTTANK program allows entry of independently determined values as well s a default selection.

The default selection to be outlined has not been widely correlated with experiment, at least not in published form, though it is known to have provided reasonable results. It is based upon the early work of Webster[4], and results in damping which is entirely quadratic. Bench tests of U-tubes often produce some non-negligible linear damping, as well as the expected quadratic damping. Since an average estimate of the linear damping in U-tube is not known, the UTTANK program arbitrarily sets β_Q to a small value-1% of critical.

The approach to the quadratic damping coefficient involves the approximation of the pressure head losses through the crossover duct as though the flows were steady. In particular, the head loss through the simplified duct is represented in the form:

$$H_\iota = \left(\sum_k C^1_{*}\right)\left[\frac{A_0}{D_c L_c}\right]^2 \frac{\left(\dot{\xi}_7\right)^2}{2g} = C_+ \frac{\left(\dot{\xi}_7\right)^2}{2g}$$

where the sum over the loss coefficients, C^1_{*}, pertains to the multiple mechanisms which by contribute to the head loss. The various loss coefficients, C^1_{*} are assumed to be estimated relative to the mean velocity in the duct. The squared $A_0/(D_cL_c)$ factor is to correct the reference velocity to that of the fluid at the free surface of the wing tank.

$$C_+ = \left(\sum_k C^1_{*}\right)\left[\frac{A_0}{D_c L_c}\right]^2$$

is termed the total head loss coefficient. Comparing Eq. 1 with the corresponding derivation in Webster[2], the nondimensional quadratic damping coefficient required for SMP95 input is found to be

$$\beta_Q = C_+/4$$

The default damping estimates are considered to be from three sources,

Estimated loss coefficient due to friction in the duct, C^1_{*}. Friction in the duct is estimated from an approximate representation of Moody high Reynolds Number fully turbulent pipe friction factors, a roughness of 0.002 feet or 0.0006 meters, and the length an hydraulic radius of the crossover duct. (Friction is ordinarily not the controlling part of the total loss coefficient for tanks of the present type, and accordingly, no great care has been taken with this part of the estimate.)

Sudden expansion and contraction losses together produce a loss coefficient, $C^{l}_{\pounds}$ between 0 and 1.5, depending upon the ratio of wing tank and duct cross-sectional areas, according to tabulated values assembled by Webster[4].

Longitudinal structural stiffeners are assumed to protrude into the duct about every 5 feet or 1.5 meters. Each is assumed to contribute a loss coefficient of 0.95, so that the third loss source, C^{l}_{ϑ}, will be some multiple of 0.95.

13.3.5.3 Input parameter definitions, Free-surface stabilizer

The use of an equation of the form of Eq. 1 for free-surface stabilizers is justified by some old work of Dalzell[5,6] in which it was shown that the moment generation capability of a series of free-surface stabilizers could reasonably be represented by a mechanical model which amounts to a moving weight roll stabilizer. Since the U-tube model was known to be essentially the same as the moving weight stabilizer model, it was reasonable to presume that the free-surface tank model could be squeezed into Eq. 1 as well. In fact, there is little squeezing necessary. The same parameters which were interpreted differently for the U-tube are interpreted differently for the free-surface tank.

I_W The transverse waterplane inertia is computed in exactly the same manner as for any other tank on the ship.

$\nleftarrow$ is $\left(Z_0 + h/2 - \overline{KG}\right)$ where Z_0 is the height of the tank bottom above the keel, h is the depth of water in the tank, and $\overline{KG}$ is the height of the ship center of gravity above the keel.

ω_t is not estimated in anything like the same way as in the U-tube case.

13.3.5.4 Some approximations for free-surface tank input

For the same reasons mentioned in connection with U-tube approximations, a pre-processor program called FSTANK was developed to ease the preparation of SMP95 input for free-surface tanks. As in the former case, the tank geometry is simplified for this purpose. Figure 2 indicates the simplified geometry, where the upper diagram is of athwartship section through the tank and the lower is the planform. Everything except the depth of water, *h*, is in the plan of the free-surface tank. The thwartship overall length is denoted B_t, and the length of the crossover channel by B_c. Similarly, the (fore and aft) width of the wing tank is denoted by L_t and the width of the crossover channel by L_c.

Free-surface tanks come in three flavors: "H" type, "C" type, and "Rectangular". Figure 2 indicates the "H" type. In the "C" type, one side or the other of the crossover channel is aligned with the forward or aft end of the wing tanks, according to the location of the transverse ship bulkhead against which the tank is placed. For present purposes there is no difference between an "H" type tank and a "C" type. The Rectangular tank has no constriction of the crossover channel ($L_c = L_t$). The flow is controlled to some extent by "picket fences" which are ordinarily placed near the quarter points of the tank.

Free Surface Anti-Roll Tank

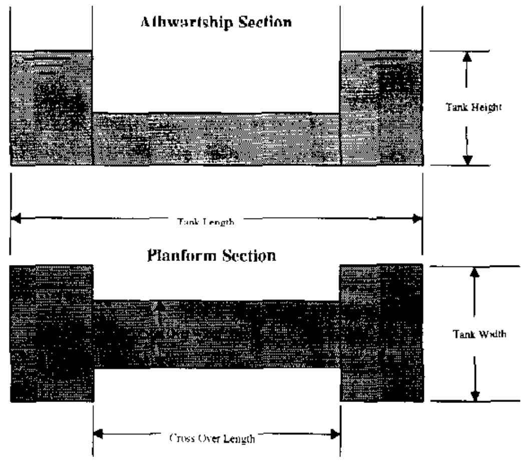


Fig. 2. Terminology, Simplified Free-surface Tank

A reasonable estimate of tank period is obtained by means of an "effective length" concept under which the tank frequency is estimated by the formula for the frequency of an unobstructed tank of a different than physical length[5]. For the free surface tank the "effective length", B_E, is estimated by:

$$B_E = B_t + B_c\left[\frac{L_t}{L_c} - 1\right]$$

and then the tank frequency by:

$$\omega_t = \sqrt{\frac{g\pi}{B_E}}\tanh\left(\pi\frac{h}{B_E}\right)$$

Note that for the rectangular tank the formula yields $B_E = B_t$, and tank frequency is what would be expected physically.

As far as damping is concerned, there is no physical way to proceed with estimates. The work on the mechanical model analogy[5] suggested on the basis of analysis of an extensive series of experiments on one parent H type tank and one rectangular tank[6] that the effective damping could be modeled s entirely quadratic. Thus, the default linear damping in the FSTANK preprocessor is $\beta_L = 0$.

The analysis of the same old experiments suggested an empirical non-dimensional form for the quadratic coefficient, which, when translated into present notation and the conventions of Eq. 1, becomes:

$$\beta_Q = C^* \frac{g^2}{\omega_t^2 \Re \mathrm{B}_t}$$

where $\Re$ is the offset of the point at which ξ_7 is defined and:

$C^* = 6.6$ for Rectangular tanks

$C^* = 5.0$ for H type tanks

It should be noted that the database on which these results are based is slim. The reasons why the result is suggested for preliminary purposes are; 1) no other approach besides bench testing is known, and 2) the values of C^* are relatively close for two tanks of widely varying shape.

13.3.6 MOVING WEIGHT STABILIZERS

The moving weight stabilizer consists of a weight which is constrained to move a thwartship on some sort of track, springs to provide a restoring force, and some form of damping device. There have been very few moving weight stabilizers built, and it is doubted that there is much demand. The capability to treat this type of stabilizer has been incorporated primarily because the incorporation consumed very little time.

The program is signaled to set up the moving weight stabilizer equations in a somewhat different way by the input stabilizer type specification. Once all the coefficients of the various motions are reduced to numerical form, there is no difference in the programming of the solutions for stabilized motions. As far as the program is concerned, at the outset the equation for the moving weight stabilizer is as follows:

$$m_7 \dot{\xi}_2 + m_7 \left[g \xi_4 - \ddot{\xi}_4 \right] + m_7 \overline{\mathrm{X}} \ddot{\xi}_6 +$$

$$m_7 \left[\ddot{\xi}_7 + \omega_t^2 \xi_7 \right] + 2 m_7 \omega_t \beta_L \dot{\xi}_7 + \frac{m_7 \omega_t^2}{g} \beta_Q \left| \dot{\xi}_7 \right| \dot{\xi}_7 = 0$$

(3)

where the units of the equation are force, and:

ξ_2, ξ_4, ξ_6 are the ship sway, roll and yaw motions as in the tank equation.

ξ_7 is the a *thwartship* linear motion of the weight. (In the tank case the use of a vertical motion of tank fluid required a location parameter, $\Re$, which is absent here.)

m_7 is the mass of the moving weight. The actual input to the program is the volume, ∇, of the equivalent mass of the water in which the ship floats. Thus the mass is computed as $m_7 = \rho\gamma\nabla$.

$\overline{X}$ is the longitudinal location of the stabilizer with respect to the ship longitudinal center of gravity.

$\mathcal{J}$ is the vertical location of the weight relative to the ship vertical center of gravity.

ω_t is the stabilizer natural frequency (rad/sec).

β_L is a nondimensional linear damping coefficient.

β_Q is a nondimensional quadratic damping coefficient

Since this stabilizer is a mechanical device, estimates of the natural frequency, and perhaps the damping coefficients, are likely to be possible from first principles from the basic mechanics of the system.

13.3.7 REFERENCES

1. Webster, W. C., J. F. Dalzell, and R. A. Barr, "Prediction and Measurement of the Performance of Free-Flooding Ship Anitrolling Tanks," *SNAME Transactions,* Vol. 96 (1988).

2. Webster, W. C. and P. Dogan, "The Analysis of the Control of Activated Anti-roll Tanks," Hydronautics, Incorporated, Technical Report 490-2 (Dec 1966).

3. Webster, W. C., "Analysis of the Control of Activated Antiroll Tanks," *SNAME Transactions,* Vol. 75 (1967).

4. Webster, W. C., "The Design of Tanks for use in an Active Tank System," Hydronautics, Incorporated, Technical Report 490-3 (July 1967).

5. Dalzell, J. F., "Initial Development of a Nonlinear Mechanical Model for the Moment Response of Free-surface Roll Stabilization Tanks," Southwest Research Institute, Technical Report No. 3, Contract Nonr-3926(00) (Mar 1966).

6. Dalzell, J. F., "An Experimental Parameter Study of the Fluid Force and Moment Response of Two Typical Ship Roll Stabilization Tanks," Southwest Research Institute, Technical Report No. 2, Contract Nonr-3926(00) (Feb 1966).

13.4 SWMP96 SWATH Regular Wave Module Input File

To be provided.

13.5 SWMP96 SWATH Irregular Wave Module Input File

To be provided.

13.6 SEP96 Seakeeping Evaluation Module Input File

SEP was developed to be used in conjunction with exploratory projects. In order to reduce computation time, SEP was developed so that it can be entered at various points. In this way, previously generated files can be utilized. This reduces computation time and cost. However, by introducing this flexibility, some complexity is introduced into the form of the input data.

Descriptions of input variables are given below. All variables in any one data set are defined by on READ statement. In some cases, data sets are described as being required only if some other variable has a particular value. That is, in some cases the data set will not be defined at all – no blank lines are required.

In the information below, variables are listed, followed by the appropriate formats and descriptions of values which may be given to variables. This information is followed by Table 9-4-1 which indicates conditions and corresponding required data sets, and Table 9-4-2 which gives some scenarios which might be run, and what files will be used and created. The information in these tables is an extraction from the information given below.

(Note: ♦ denotes a blank required in A type fields.)

13.6.1.1 Record Set 1, Title

Record 1 – FORMAT (8A10)

-[TITLE](Character) - is the title which will be used in the output file for this assessment.

13.6.1.2 Record Set 2, Analysis Type

Record 1 - FORMAT (5A8)

-[SHPTYP](Character) - Indicates ship type for analysis.

MONOHULL- for monohull type ships.

SWATH♦♦♦ - for SWATH type ships.

-[OCEAN](Character) - Denotes ocean basin for analysis.

PACIFIC♦ - North Pacific ocean basin.

ATLANTIC♦ - North Atlantic ocean basin.

GENERAL♦ - Generic ocean basic.

-[SEASON](Character) - Selects the seasonal statistics to be used for the analysis.

ANNUAL♦♦ - denotes that annual wind wave statistics be used.

WINTER♦♦ - Data for the winter months (December, January, and February) was used for the wind wave statistics.

BOTH♦♦♦♦ - Apply both sets of statistics for the analysis.

-[WIND](Character) - Determines if the analysis will include the effects of wind.

WIND♦♦♦♦ - program will include effect of wind on operability, through use of relative wind envelopes.

NOWIND♦ - no consideration will be given to wind effects.

-[SOWMDAT](Character) - Determines which components of the SOWM data base are used for the analysis.

WAVEWIND - program will use modal period-significant wave height - wind speed joint probability of occurrence data. NOTE: Relevant only if WIND=WIND◆◆◆◆. In this case, the absolute wind values considered will be those used in generating the SOWM data base. Wind speed distribution data is currently available for the North Atlantic only.

WAVE◆◆◆ - program will use modal period-significant wave height joint probability of occurrence data.

NOTE: Used whenever WIND=NO WIND◆. If WIND=WIND◆◆◆◆, the absolute wind speed will be represented as a function of significant wave height, according to input data (see Record Set 14).

NOTE: The required SOWM database file will be accessed by SEP, depending on the definitions given to OCEAN, SEASON and SOWMDAT.

13.6.1.3 Record Set 3, RMS File Controls

Record 1 - FORMAT (4I5)

ILCEVAL and ISCEVAL indicate what type of seakeeping evaluations are to be carried out in this computer run.

-[ILCRMS](Integer) - Indicates the availability of the longcrested RMS file.

1 - program will use longcrested RMS file which was previously generated and is available as MLC.SEP.

NOTE: An existing MLC file can be used in subsequent runs of SEP to carry out other evaluations. The motion criteria (WCRIT), the vertical locations for wetnesses (ZWET) or slams (ZSLAM), the weights (IHVWT(I,J)), and geographical locations of interest can be different. However, in order for the results to be correct, an existing MLC file must have used the identical longitude and transverse values for the points of interest on the ship, as those which are required for the current evaluation. Check the computer output to verify that the intended data has been utilized.

0 - if longcrested RMS file MLC.SEP is not available. In this case, if a longcrested assessment is required (i.e., ILCEVAL=1), a file MLC will be automatically generated form file MTF.SEP.

-[ISCRMS](Integer) – Indicates the availability of the shortcrested RMS file.

1 - program will use a shortcrested RMS file, which was previously generated and is available as file MSC.SEP.

NOTE: As with the case where ILCRMS is defined as 1, a previously generated shortcrested RMS file can be used, only if the same points on the ship are of interest. (See note for ILCRMS = 1 above.)

0 - if shortcrested RMS file MSC.SEP is not available. In this case, if a shortcrested assessment is required (i.e., ISCEVAL = 1), a file MSC.SEP will be automatically generated from file MLC.SEP, when ILCRMS = 1, or from file MTF.SEP.

-[ILCEVAL](Integer) - indicate that longcrested seakeeping evaluations are to be carried out.

1 - to have longcrested seakeeping evaluation done.

0 - for no longcrested seakeeping evaluation.

-[ISCEVA1](Interger) - indicate that longcrested seakeeping evaluations are to be carried out.

1 - to have shortcrested seakeeping evaluation done.

0 - for no shortcrested seakeeping evaluation.

13.6.1.4 Record Set 4, Program Options

Record 1 – FORMAT (3I5)

-[IHALT](Integer) - Determines the type of run to perform.

1 - to terminate execution of the program after data has been read in, echoed to the output, and preliminary calculations have been made. The program execution will then be terminated prior to the time-consuming RMS calculations. In this way, the program user can verify that the correct options have been specified and that the intended transfer function (MTF) or RMS (MLC or MSC) files have been accessed.

0 - to carry out the seakeeping assessment, without stopping.

-[LINM](Integer) - indicates units used for input data. Units for input on the file MIN must be consistent with those on the file MTF or the file ORGFIL.

1 - if metric units are used for input variables.

0 - if English units are used for input variables.

-[LOUTM](Integer) - Determines the units on dimensional properties output from SEP.

1 - if metric units are to be used for printed output values.

0 - if English units are to be used for printed output values.

13.6.1.5 Record Set 5, Active Fin Gains

Define only if SHPTYP is defined as SWATH♦♦♦.

Record 1 - FORMAT (I5)

-[IGAIN](Integer) - indicates the availability of the MGAIN.SEP file for use in the analysis.

0 - for all monohulls or for any SWATH with fixed stabilizing fins.

1 - for SWATHs with active stabilizing fins. Values below indicate choices of information which will be written to file MOUT.SEP.

13.6.1.6 Record Set 6, Roll Transfer Function

Record 1 – FORMAT (2I5) Define only if SHPTYP = monohull and ILCRMS = ISCRMS = 0.

-[IROLLA](Integer) – determines which roll transfer function will be used. IROLLA specifies which set of transfer functions, with corresponding mean roll angle, will be accessed from the SMP file ORGFIL.

1 - for 0.5 degree mean roll angle transfer functions

2 - for 1.0 degree mean roll angle transfer functions

3 - for 2.5 degree mean roll angle transfer functions

4 - for 5.0 degree mean roll angle transfer functions

5 - for 10.0 degree mean roll angle transfer functions

6 - for 15.0 degree mean roll angle transfer functions

7 - for 25.0 degree mean roll angle transfer functions

8 - for 40.0 degree mean roll angle transfer functions

-[IECHOMO](Integer) - Determines if the transfer function is written to the output file.

1 - to write transfer functions from ORGFIL.SMP to MOUT.SEP.

0 - to not write transfer functions to MOUT.SEP.

13.6.1.7 Record Set 7, Ship Locations for Evaluation

Define only if starting with transfer functions form file MTF or file ORGFIL (i.e., ILCRMS = ISCRMS = 0)

Record 1 – FORMAT (8F10.5)

STA(I), YAR (I), and ZAR(I) define the coordinates of the Ith point on the ship which will be used in the seakeeping evaluation.

-[STAT(I)](Real) - is the station number of the point of interest, relative to the forward perpendicular, where 20 stations = ship length overall.

-[YAR(I)](Real) - is the distance between the ship centerline and the point of interest, with port positive.

-[ZAR(I)](Real) - is the distance between the calm waterline and the point of interest, with up positive.

where values of I and corresponding ship responses or events are:

1 - location for wetnesses (or emergencies)

2 - location for slams

3 - location for absolute vertical displacement

4 - location for absolute vertical velocity (usually the helo pad)

5 - location for absolute vertical acceleration (often the pilot house)

6 - location for relative vertical displacement (usually the bow)

7 - location for lateral acceleration

8 - location for calculation of Lateral Force Estimator (LFE)

NOTE: ZAR(1) and ZAR(2) must be set to zero. These locations are defined using ZWET and ZSLAM (see Record Set 10. below).

13.6.1.8 Record Set 8, Motion Criteria

Record 1 – FORMAT (8F10.5)

-[WCRIT(I)](Real) - are the seakeeping motion criteria values. When a value of 0 is entered, default values are utilized. The default values are given in brackets after each description below.

NOTE: In order to eliminate a criterion from consideration, set the appropriate value of WCRIT(I) to a large number such as 999.

Values of I, corresponding ship responses or events, and default values are:

1 - roll (deg.) significant amplitude [8 deg]

2 - pitch (deg.) significant amplitude [3 deg]

3 - wetnesses per hour [30]

4 - slams per hour [20]

5 - significant amplitude of absolute vertical displacement [7.0 ft = 2.13 m]

6 - significant amplitude of absolute vertical velocity [6.5 ft sec=1.98 m/sec]

7 - significant amplitude of absolute vertical acceleration, given in g's [0.4]

8 - significant amplitude of relative vertical displacement [999 m.]

9 - significant lateral acceleration, given in g's [0.14]

10 - LFE (Lateral Force Estimator) in g's [999]

11 - 0 (not currently used)

12 - 0 (not currently used)

Give the following variables nonzero values only if IGAIN>0.

13 - not exceeded by more than 1 stern fin excursion in 10 [20 deg]

14 - not exceeded by more than 1 stern fin excursion rate in 100 [10 deg/sec]

15 - not exceeded by more than 1 forward fin excursion in 10 [20 deg]

16 -not exceeded by more than 1 forward fin excursion rate in 100 [10 deg/sec]

13.6.1.9 Record Set 9, Wetness and Slamming Locations

Record 1 - FORMAT (2F10.5)

-[ZWET](Real) - vertical location of point of interest, relative to the calm waterline, for wetnesses/ hour calculation (ZWET > 0), for emergences/hour (ZWET < 0)>

-[ZSLAM](Real) - vertical location of point of interest, relative to the calm waterline of point for slams/hour calculation, where ZSLAM > 0 for a point above the waterline. ZSLAM should be given in the units indicated by LINM.

13.6.1.10 Record Set 10, SOWM Database

Record 1 - FORMAT (I5)

-[NLOC](Integer) - number of geographical locations in the SOWM database for which operability is to be accessed.

0 - if composite and all points in the accessed database are to be used (includes case where map plots will be done).

Record 2 – FORMAT: (2I5), Define only if NLOC >0.

-[JGP] (Integer) - grid point of geographical point for which seakeeping evaluations will be performed (see Tables 9A.1 and 9A.2 for lists of acceptable Values).

-[JSB](Integer) = sub-projection of geographical point for carrying out seakeeping evaluation (see Tables 9A-1 and 9A-2 for lists of currently acceptable values).

NOTES: Composite data sets are available for the General North Atlantic Ocean, General North Pacific Ocean, and Annual (all months or Winter (December, January, and February)). At least one composite data set is available on each of the SOWM files as discussed on page 9-41. To utilize this data, JGP and LSB are equated and defined as described in the following paragraphs.

All four composite sets can be accessed when OCEAN has been defined as GENERAL, and SEASON has been defined as both. In this case, only the four composite sets are available. For the North Atlantic Ocean, Annual, define JGP and JSB as 991; for Winter, define JGP and JSB as 992. For the North Pacific Ocean, Annual, define JGP and JSB as 993; for Winter, define JGP and JSB as 994.

When OCEAN has been defined as ATLANTIC or PACIFIC and SEASON has been defined as ANNUAL or WINTER, then define JGP and JSB as 999 to use the composite data sets. In these cases, the data for the geographical points listed in Tables 9A.1 and A.2 also are available.

13.6.1.11 Record Set 11, PTL Plot File Generation

Record 1 - FORMAT (I5)

-[IPLMAP](Integer) - Determines the type of plot to generate plots of PTO values or contour curves of constant values of PTO on maps.

10 - to generate plots utilizing data stored on file MAP.SEP generated in a previous computer run. (Most of the input data is then meaningless. Define ILCRMS as 1 to reduce the amount of required data.)

1 - to have PTO values or contour curves of constant values of PTO generated on maps.

0 - to have no map plots.

Record 2 - FORMAT (3I5) Define only if IPLMAP > 0.

-[IPLPTS](Integer) - Determines if PTOs will be plotted.

1 - to plot values of PTO, at corresponding geographical point on map

0 - to not plot PTO values

-[ICONTUR](Integer) - draw contour lines, corresponding to constant values of PTO. The larger the value given ICONTUR, the thicker the line will be.

>0 - Draw contour lines, line thickness based on magnitude of ICON-TOUR.

0 - to not draw contour lines.

-[IPLVAL](Integer) - Determines which PTO value is plotted.

0 - to have the weighted average PTO values plotted.

1 - to have the weighted average PTO values with wind effects plotted. Use only when WIND = WIND◆◆◆◆.

2 - to have the weighted average PTO values with wind effects plotted.

3 - to have the minimum of PTO (with wind effects if WIND =WIND◆◆◆◆) values plotted.

4 - to have the maximum of PTO (with wind effects if WIND = WIND◆◆◆◆) values plotted.

5 - to have the best speed/heading PTO values plotted.

Record 3 - FORMAT (4A10) Define only if IPLMAP > 0.

-[MAP(I)](Character) - Title to be placed on the map plot

13.6.1.12 Record Set 12, Speed Heading Weighting Functions

Record 1 - FORMAT (2I5)

-[IEQWTS](Integer) - Determines if ship speeds and headings are to be generated by SEP

1 - if all ship speeds and headings are equally likely. In this case, SEP will generate values.

0 - if speed-heading weights are not equally likely. In this case, the program user must input values.

-[IWT360](Integer) - Determines if the speed-heading function is symmetrical about ship's axis.

1 - if the speed-headings weights are asymmetrical about the head-following seas axis and the entire array covering 0 to 360 will be specified. (See Data Set 12a below.)

0 - if speed-heading weights are symmetrical about the head-following seas axis and values for only half the possible values will be input.

Record 2 – FORMAT (24I3) Define only if IEQWTS = 0. (i.e., all speeds and headings are not equally weighted.)

-[IHVWT (I,J), I = 1, NHEDT,J = 1, NSPEED)](Real) - represents the speed-heading weights or profile of the ship for the Ith heading and Jth ship speed.

where NSPEED:

for monohulls NSPEED = VKDES/VKINC +1, VKDES and VKINC are SMP91 input variable.

for SWATHS NSPEED is an SWMP input variable.

where NHEDT = NHEAD + (IWT360) (NHEAD - 2). That is, when IWT360 is set to 1, flagging asymmetrical weighting, then NHEDT will equal NHEAD, the number of relative wave headings. For shortcrested seas NHEAD is 13 or 24, depending whether IWT360 is 0 or 1.

NOTE: If IWT360 = 0 and headings are to be equally weighted for a particular speed, define weights for wave heading angles other than head and following seas as twice those for head and following seas. This effectively includes all responses, with headings form 0 to 360 degrees, even though motion responses are available only from 0 to 180 degrees.

13.6.1.13 Record Set 13, Wind/Wave Normilzation Factor.

Record 1 - FORMAT (I5) Define only if WIND = WIND♦♦♦♦.

-[NORM](Integer) - NORM affects the calculation of the values of PTO calculated as a function of significant wave height when wind envelopes (WIND = WIND♦♦♦♦) are utilized.

0 - PTO = 100 times the sum of the joint probabilities of occurrence of significant wave height, spectral modal period, and wind speed, where motion criteria are not exceeded, and the wind envelope indicates that air operations are possible (usual definition).

1 - PTO = 100 times the sum of the joint probabilities of occurrence of: significant wave height, spectral modal period, and wind speed, where motion criteria are not exceeded and the wind envelope indicates that air operations are possible; divided by the sum of the joint probabilities of occurrence of those conditions, when the wind envelope indicates air operations are possible.

(The difference between results obtained using NORM = 0 and NORM = 1 can be demonstrated by an example. Assume all speeds and headings are equally weighted, that the wind envelopes indicate that for all wind speeds air operations are possible for one ship-heading combination, and that for that speed-heading, the motion limits are not exceeded for any spectra which might occur. When NORM = 1, the PTO would be 100. When NORM = 0, the PTO would be 100 divided by the product of the total number of speeds and the total number of headings.)

Record 2 – FORMAT (8F10.5) Define only if WIND = WIND.

The variables OPHDG1 and OPHDG2 are used to represent a particular relative wind envelope for the hull form. A relative wind envelope can be defined during a full-scale trial. It represents the combination of the wind speed relative to the ship speed and the ship heading angle relative to the wind angle, for which the hull form can carry out a particular air operation without degradation in performance. Refer to Figure 9-4-1.

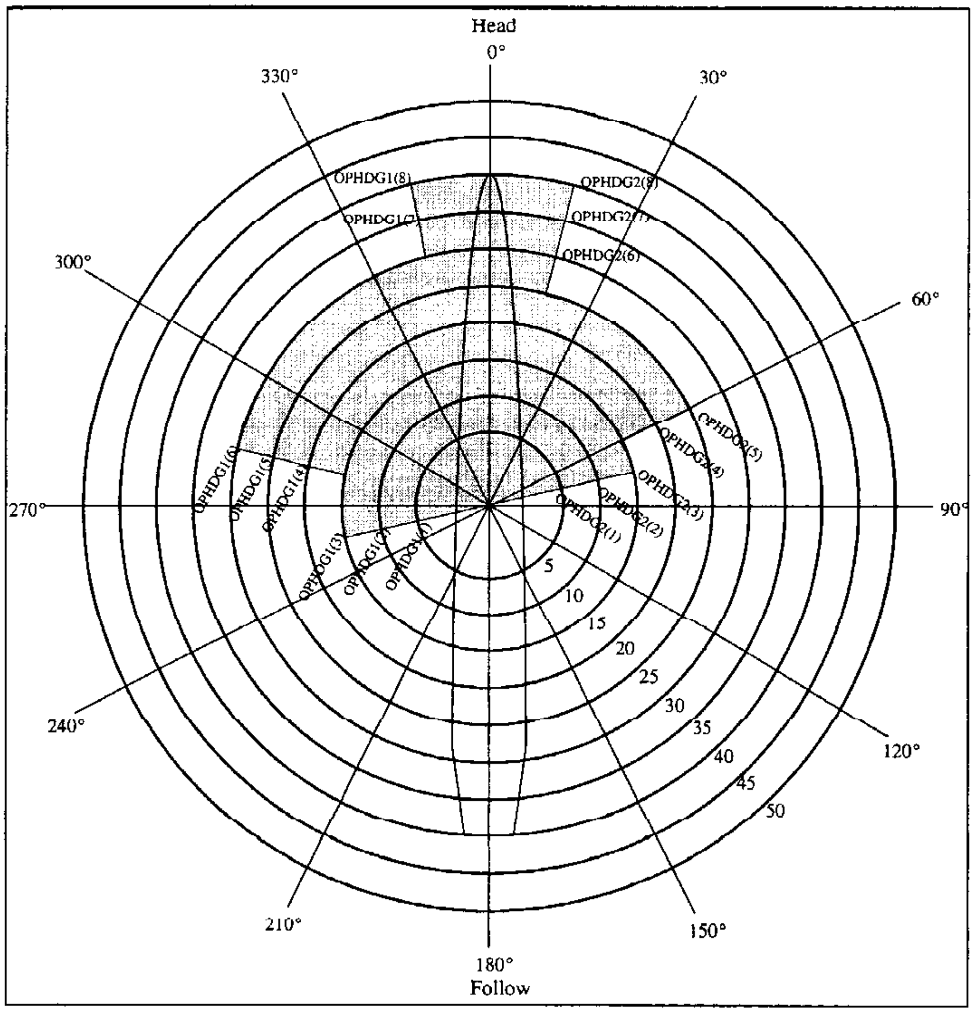


FIGURE 9-4-1. Clearance Wind Envelope

-[OPHDG1(I), I=1,10 (Real) - Progressing clockwise, first heading of the ship relative to the heading of the wind, at which the air operation can be carried out for relative wind speeds between 5 (I-1) and 5 I knots. Given in degrees.

-[OPHDG2(I), i=1,10) - Progressing clockwise, last heading of the ship, relative to the heading of the wind, at which the air operation can be carried out for relative wind speeds between 5(I-1) and 5 I knots. Given in degrees.

NOTE: I varies from 1 to 10, so that OPHDG1 and OPHDG2 must be defined for relative wind speeds varying from 0 to 50 knots.

NOTE: 0 = head seas, 180 = following seas. Port beam is 270.

Example: For a particular relative wind speed, a particular air operation can be performed when the relative heading is between port beam and starboard beam, including head winds. OPHDG1 (I) = 270., and OPHDG2 (I) = 90.

13.6.1.14 Record Set 14, Absolute Wind Speed

Record 1 FORMAT (5F10.5) Define only if WIND♦♦♦♦ and SOWMDAT = WAVE♦♦♦.

These variables are used to define absolute wind speed, V_w, as a function of significant wave height, $\xi_{1/3}$. The following relationship is used.

$$V_w = c_0 + c_1 \xi^{P1}{}_{1/3} + c_2 \xi_{1/3}{}^{P2}$$

where V_w is in knots, $\xi_{1/3}$ is in the meters, and c_o, c_1, c_2, and p_2 are defined by the input variables CO, C1, P1, C2, and P2, respectively.

-[CO](Real) - curve fit constant

-[C1](Real) - curve fit constant

-[P1](Real) - curve fit exponent

-[C2](Real) - curve fit exponent

-[P2](Real) - curve fit exponent

NOTE: This record set is obsolete, the wave wind database is more accurate.

13.6.1.15 Record Set 15, Confidence Bands for LSWH

Record 1 - FORMAT (I5) Define only if WIND = NO WIND♦.

-[NBAND](Integer) - the number of confidence bands used in determining the Limiting Significant Wave Heights. (LSWH).

Record 2 - FORMAT (2I5) Define only if WIND = NO WIND♦.

-[JBAND(I), I=1,NBAND](Integer) - 95 and/or 50. This relates to determining the LSWH. For each significant wave height band, the spectra considered will be those which encompass 95 or 50 percent of the spectra which occur, including the most probable spectral modal (peak) period.

13.6.1.16 Record Set 16, Print Options

Record 1 - FORMAT (5I5)

These variables determine what seakeeping evaluation or RMS data is written to the file MOUT. There are two evaluation-related tables which are always presented: one summarizes the LSWH PTOs for geographical point used in the evaluation; one presents the LSWHs and corresponding failing criteria for all modal periods, ship speeds, and relative wave headings. These are the last two tables on the file MOUT.

-[ISEAW](Integer) - controls which tables of seaworthiness evaluation data are presented for individual geographical points. Values are given as a function of ship speed and relative wave heading. The LSWH is calculated only when WIND = NO WIND. The LSWH is calculated for the specified confidence band(s).

0 - LSWH (Limiting Significant Wave Height)

1 - LSWH + PTO (Percent Time of Operation)

2 - LSWH + PTO + FC (Failing Criteria table)

3 - LSWH + PTO + FC

4 - LSWH + PTO + FC for the General North Atlantic Ocean or the General North Pacific Ocean. Tables are not written for any specific geographical points considered.

-[JPRMS](Integer) - controls the form of the longcrested RMS data that is written on the file MOUT. This variable applies only to the runs where MLC is being written (i.e.,ILCRMS = 0. and ILCEVAL = 0 or ISCEVAL = 0.

0 - no RMS data.

1 - writes RMS values for all the six-degrees-of-freedom motions and for motions at the six specified points on the ship are given. Displacements and/or velocities and/or accelerations are given, depending on the values given KPRMS and LPRMS immediately below. If AGAIN = 1, RMS values for the fin deflection displacements and velocities will also be printed.

2 - writes only values used in seaworthiness assessment.

NOTE: KPRMS and LPRMS need to be defined only if JPRMS = 1.

-[KPRMS](Integer) - applies to absolute and relative motion calculations.

0 - none

1 - absolute and relative vertical motions

2 - absolute transverse motion

3 - absolute and relative vertical motion and absolute transverse motion

-[LPRMS](Integer) – applies to 6 degrees of freedom motions and to absolute and relative motions.

0 - displacement

1 - velocity

2 - acceleration

3 - displacement and velocity

4 - displacement, velocity, and acceleration

-[IPLOT](Integer) - controls output of transfer functions and RMS values to the MPLOT file.

1 - transfer functions and RMS values will be written to the file MPLOT.

0 - data not written to a file (usual value).

Table 9-4-1. Conditions, corresponding input data variables and values, and required records sets for running SEP.

Condition	**Corresponding Input Data Variable and Value**	**Required Record Set(s)***
SWATH	SHPTYP = SWATH	5
SWATH with automatic control	IGAIN > 0	5 (all values)
Monohull	SHPTYP = MONOHULL	6
Starting with transfer functions	ILCRMS = ISCRMS = 0	7
Select geographical locations from among those on file	NLOC > 0	10a
Generate file MPLOT and/or generate DISSPLA plots	IPLMAP > 0	11a, 11b
Unequal speed-heading weights	IEQWTS = 0	12a
Wind Envelopes; Significant wave height-modal period-wind speed SOWM data	WIND = WIND◆◆◆◆ SOWMDAT = WAVEWIND	 13, 13a
Wind Envelopes; Significant wave height-modal Period SOWM data	WIND◆ = NO WIND◆ SOWMDAT = WAVES◆◆	 13, 13A, 14
No wind envelopes	WIND = NO◆ WIND◆	15, 15A

*Record Sets 1, 2, 3, 4, 8, 9, 10, 11, 12, and 16 are required for all runs.

Table 4-2: Various seakeeping evaluation scenarios, including required seakeeping evaluation and status of evaluation variables relative to previous values, files to be used, and files created.

Required Seakeeping Evaluation	Locations on Ship	Vertical Locations for Slams/ Wetnesses	Seakeeping Criteria Values	Geographical Locations	Ship Motions File(s) to be used	Ship Motions File(s) Created
LC[1]	N[2]	N or O[3]	N or O	N or O	ORGFIL[4]	MTF,MLC
LC	N	N or O	N or O	N or O	MTF	MLC
LC	O	N or O	N or O	N or O	MLC	none
SC[5]	N	N or O	N or O	N or O	ORGFIL[4]	MTF,MLC,MSC
SC	N	N or O	N or O	N or O	MTF	MLC,MSC
SC	O	N or O	N or O	N or O	MLC	MSC
SC	O	N or O	N or O	N or O	MSC	none
LC & SC	N	N or O	N or O	N or O	ORGFIL[4]	MTF,MLC,MSC
LC & SC	N	N or O	N or O	N or O	MTF	MLC,MSC
LC & SC	O	N or O	N or O	N or O	MLC	MSC
LC & SC	O	N or O	N or O	N or O	MLC & MSC	none

[1] LC=Longcrested

[2] N = New (relative to values used in creating existing files MLC or MSC).

[3] O = Old (relative to values used in creating existing files MLC or MSC).

[4] for monohull only

[5] SC = Shortcrested

13.6.2 Description of Data Files

Several data files are utilized by SEP. There are two types of files: those which must be provided by the program user and those which are generated by SEP. In the first group there are two files: a file with transfer functions (file MTF or file ORGFIL), and a file with wave spectra statistics (file MSOWM). The transfer function files are generated by the programs SWMP or Visual SMP. The wave spectra statistics files have been developed at the Naval Surface Warfare Center Carderock Division (NSWCCD). The other files are generated by SEP itself and may be used in subsequent runs.

Each file is identified by a variable name throughout the computer code. Each of these variables is assigned an integer value in a data statement in the main program of SEP. The variable name followed by its assigned integer value or range of values in parenthesis and a description of each of the data files follows.

MGAIN (3) – is an input file which is used in conjunction with SWMP and applies to SWATH ships only. It contains information related to the automatic control system of the stabilizing fins. These values are used in conjunction with assessing the limitations to acceptable performance brought about by having the stabilizers exceed deflection and deflection rate limits.

MIN (5) – is the input data file generated by the user which determines what will be done in a particular run of SEP.

MLC (8) – is a file generated by SEP. This file contains RMS (root mean squared) values from the motion transfer functions file, MTF, and the set of locations on the ship specified in MIN. It contains the RMS file required by SEP to carry out an evaluation and can be used in subsequent evaluations (see ILCRMS defined in section 9.4.). It can be used to generate the MSC file.

MMAP (10) – is a file generated by SEP. It contains variables used for generating plots on world maps. The information includes the longitude and latitude, as well as values related to the Percent Time of Operation for each geographical point. This file is accessed by other software to develop plots.

MOUT (6) – is the output file which contains the results generated by SEP.

MSOWM (11-17) – is a file which was developed at NSWCCD and which must be provided by the user. There are a series of files. Each file contains data related to the joint probability of occurrence of significant wave height, spectral modal (peak) period and, in some cases, wind speed. Only one file is used in any given run of SEP. The data is stored in formatted form to facilitate transportability between computers.

All data files have been created from Spectral Ocean Wave Model 3 data. Each data file has significant wave height bands, with center periods of 3.2, 4.8, 6.3, 7.5, 8.6, 9.7, 10.9, 12.4, 13.8, 15.0, 16.4, 18.0, 20.0, 22.5, and 25.7 seconds. There are several different files that can be used. Each has a different combination of ocean basin, seasonal grouping, and statistical parameters.

The values in the MSOWM file are determined in SEP as a consequence of the values given OCEAN, SEASON, and WIND in the input. (See Section 9.4 for definitions of these variables.) Consequently, the program user has two choices: either all data files can be made available for all runs so that control cards need not be changed for individual runs, or the data file for a particular run can be made available. The choice made will depend, in part, on the computer used.

The first set of files (listed below) presents the joint likelihood of occurrence of significant wave height and spectral modal period. The data is used when WIND = NO WIND. The likelihood is presented as the percent time of occurrence of each combination of the two parameters. Data has been developed for a composite of 57 geographical points in the North Atlantic and for each individual geographical point and for a composite of 21 geographical points in the North Pacific and for each individual point (see Tables 13-6-1 and 13-6-2).

MSOWM = 11: North Atlantic Basin, Annual
MSOWM = 12: North Atlantic Basin, Winter
MSOWM = 13: North Pacific Basin, Annual
MSOWM = 14: North Pacific Basin, Winter

The composite from these four files will be used when MSOWM = 15. The second set of files presents the joint likelihood of occurrence of significant wave height, spectral modal period, and wind speed. This data is used when WIND = WIND. The likelihood of occurrence is presented as the number of occurrences. The data has been sorted in 2.5 knot wind speed bands. Data (listed below) is currently available for the North Atlantic only:

MSOWM = 16: North Atlantic Basin, Annual
MSOWM = 17: North Atlantic Basin, Winter

MTF (7) - is a file which contains transfer function amplitudes and phases. For SWATH ships, the file is generated by SWMP. For monohull ships, this file is generated by SEP from the SMP file ORGFIL (see next file description). This file is used to generate the file MLC.

ORGFIL(4) - is a file provided by the program user which has been generated as ORGFIL by SMP. It provides the transfer function amplitudes and phases for the six degrees of freedom regular wave responses of a monohull. It is used by SEP to generate an MTF file.

Table 13-6-1: Geographical points in the North Atlantic Ocean, which are accessible in the SEP Special Ocean Wave Model database.

Grid Point	Sub-Projection Point	Latitude (deg. N.)	Longitude (deg.)
38	3	67.69	-.43
37	3	66.60	6.77
62	3	65.69	-5.85
87	3	63.78	-24.15
84	3	62.85	-3.92
107	3	61.10	-14.64
110	3	60.70	-33.12
111	3	60.50	-38.74
129	3	58.60	-24.02
128	3	58.58	-18.17
127	3	58.29	-12.30
132	3	57.21	-40.26
149	3	55.87	-26.65
124	3	55.87	4.39
147	3	55.80	-15.75
134	3	55.40	-49.35
169	3	52.75	-33.77
304	2	52.61	-49.92
171	3	51.55	-42.67
184	3	50.58	-21.47
182	3	50.02	-11.74
187	3	49.95	-35.40
279	2	46.19	-44.89
216	3	45.20	-21.65
218	3	45.10	-30.15
215	3	45.00	-17.28
277	2	44.81	-53.06
214	3	44.64	-12.91
269	2	44.05	-42.07
257	2	41.35	-43.29
244	3	39.91	-21.79
247	2	39.79	-33.23
242	3	39.33	-13.87
263	2	38.77	-65.14
Grid Point	Sub-Projection Point	Latitude (deg. N.)	Longitude (deg.)
243	2	37.88	-48.22

261	2	36.13	-71.81
240	2	35.13	-59.26
220	2	34.96	-29.00
228	2	34.10	-52.86
265	3	33.75	-11.05
216	2	33.40	-42.98
203	2	32.00	-33.67
214	2	31.95	-50.16
224	2	29.75	-66.53
287	3	29.67	-18.68
211	2	29.02	-60.53
182	2	26.69	-48.50
151	2	24.45	-30.94
207	2	24.23	-72.80
161	2	20.84	-59.11
127	2	19.20	-44.70
124	2	16.69	-54.18
69	2	15.45	-24.32
139	2	14.74	-68.37
85	2	14.08	-43.45
81	2	10.82	-55.52
18	2	9.18	-31.93

Table 13-6-2: Geographical points in the North Pacific Ocean, which are accessible in the SEP Special Ocean Wave Model database.

Grid Point	Sub-Projection Point	Latitude (deg. N.)	Longitude (deg.)
121	3	56.38	-171.71
28	3	51.35	162.52
124	3	51.31	-158.82
164	3	50.89	-145.65
56	3	50.03	-178.91
202	3	43.73	-128.73
148	3	43.17	-141.43
93	2	42.81	159.01
39	3	37.52	-158.01
294	1	36.32	148.51
188	3	36.16	-127.36
88	3	34.90	-145.58
85	2	34.48	-174.21
152	2	34.16	163.78
239	1	26.51	135.84

255	1	26.02	148.20
165	2	25.19	-179.77
102	2	24.78	-162.46
93	3	24.58	-135.65
121	4	24.25	-116.34
233	2	20.60	163.06

13.7 STH97 Standard Time History Module Input File

To be provided.

INDEX

P

R

S

T

U

V

W